PRACTICAL INFORMATION

FOR

TELEPHONISTS,

BY

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PREFACE.

No science is so pre-eminently the science of the age as that of Electricity; nor is any study so fascinating, or so enthralling to its votaries; and, when associated with its elder sister, "Magnetism," to work modern miracles, it is not for any living creature to limit the number, character or scope of its manifestations.

Justly prominent amid those manifestations stand the electrical transmission and reproduction of articulate speech; and to the fact that these ends have been accomplished, and that in consequence thereof a new industry has arisen, spreading itself over the civilized world in the short space of five years, are due the production and publication of the papers of which this little volume is composed.

Most of the articles were originally written for, and have already appeared in, THE OPERATOR; but in preparing them for publication in book form, they have all been carefully revised by the author, and, in nearly every instance, more or less re-written. They were all written with pleasure to the author, and with the desire that they might be not only interesting but profitable to the reader.

This book is not put forward as a text-book of electrical science, a manual of telegraphy, or even as a complete hand-book of the telephone; neither is it intended so much for the delectation and instruction of professional and accomplished electricians as a popular means of conveying practical ideas, mainly proved to *be* practical by actual practice, to that large and daily increasing constituency of telephone inspectors and operators; and, also, to the equally large class of amateurs who, by the spirit of the age, have become interested in the electric telephone and its practical application.

Very few technical terms have been used, and a light and sugar-coated style has in many cases been adopted, which, it is hoped, will aid in the assimilation of the solid food; and attract some persons to read who would shun with faintly-disguised horror the profound

axioms, the didactic theorems, and the abstruse equations with which wiser men have adorned and illustrated more pretentious books. In fact, it is the modest boast of the author that no algebraic equation or erudite expression of differential calculus finds place within these pages.

Both the author and the publisher have in various ways become acquainted with the fact that these papers have been read—in many cases, by men who do not often read—and they are proportionately gratified by such a knowledge. They have both, also, frequently received letters inquiring for the numbers of the paper in which these articles were printed, and they therefore believe that their publication in the present substantial form, will subserve the double purpose of a reply to such letters and a supply of the desired back numbers.

It must not be forgotten by those who differ from any views herein expressed that the writer, not being at present actively concerned in the management of any telephone exchange, is compelled to confine himself to generalities, and to indicate the methods which, subject to modifications by individual conditions, would be employed by himself; and, therefore, to glean the greatest profit from these pages, each reader must in practice make the requisite variations from the text to suit his own case.

If anything read in these pages shall tend to arouse ambition in the breast of youth, to cause a desire for self-improvement in any telephone employé, to implant zeal in a hitherto listless inspector, or to elucidate to any youthful aspirant to electrical or telephonic honors the daily and hourly problems of a telephone exchange, the aim of the writer will have been attained, and satisfaction will reign in his heart.—*Pax Vobiscum.*

Practical Information for Telephonists.

HISTORICAL SKETCH OF ELECTRICITY FROM 600 B. C. TO 1882 A. D.

On the sea-coast of Prussia, and indeed throughout the whole length of the Baltic coast, is found a hard, brittle substance, with a resinous lustre, sometimes found perfectly transparent, but more usually of varying degrees of translucency. It possesses a prevailing yellow color, passing from a pale, straw tint, to a deep orange. It is found in irregular masses, and has no taste, nor, at ordinary temperature, odor.

Named by the Romans, "Electrum;" in our own language, "Amber;" by the French, "Ambre;" and by the ancient Greeks, "Electron;" this substance has been known from the earliest ages; and is chiefly known at the present time as being the beautiful straw-colored substance that furnishes material for the mouthpiece of the fragrant meerschaum or holder of the luscious Havana.

But what has this to do with the mysterious and ubiquitous force?—Well, not much; only, were it not for the fact that some ancient fossil of a philosopher, whose name has not been handed down to us, while one day rubbing a piece of amber (or as he, being a Greek, called it, "Electron"), found that after a little friction had passed between him and the amber, it

acquired the property of attracting and repelling light bodies. This little passage at arms is the first record that we have of the manifestation of electricity. The force causing these manifestations was called "Electricity," by Dr. Gilbert, an English philosopher of the sixteenth and seventeenth centuries. The name at that time proved as popular as the science has since become; and to-day, while comparatively few persons know that amber was once called "Electron," every one knows that the force of which we *know* nothing is called Electricity.

Except that the bare fact already mentioned was subsequently described by Thales of Miletus, 600 B. C.; by Plato, who gave the first electric theory, 400 B. C.; by Theophrastus, 321 B. C., and by Pliny, 70 A. D., the science virtually stood still until about 1600 A. D., when Dr. Gilbert once more set the ball rolling, by a vigorous series of experiments; he found that many substances besides amber would also exhibit electrical phenomena; and concluded his career by writing a book which he called "De Magnete," in which he made public his arduous labors.

Between 1627 and 1691 A. D., Robert Boyle added many new facts to the science, and discovered among other things that amber retained its attractive virtues, even after the exciting cause ceased. He also wrote a book, which he called "Experiments on the Origin of Electricity." About 1690 Otto Von Guericke, the contemporary of Boyle, discovered that light and sound accompanied electrical excitation. He also wrote a

book; and, calling it by the learned Latin name of "*Experimenta Nova Magdeburgica*," records the fact that the light obtained from frictional electricity resembles that exhibited by the breaking of sugar in the dark; thus imparting information on a subject of which we had hitherto also been in the dark; *viz.*, whether the ladies and gentlemen of the middle ages were accustomed to sweeten their tea, or to drink it in its pure state. Sir Isaac Newton, in 1675, added his quota to the list of electrical discoveries, by ascertaining that glass could be electrically excited in the same manner as amber. In 1705, and until 1712, Francis Hawkesbee added new facts to the science, and remarked the resemblance of electrical light to lightning. He described his discoveries in his "Physico Mechanical Experiments." Dr. Wall, about the same time, remarked the same similarity, as above mentioned.

Stephen Gray, a Fellow of the Royal Society, is the next link in the chain of electrical science; and was most ardent in the pursuit of electrical knowledge under difficulties. A decided epoch in the science was reached by his discovery that some bodies had, while others had not, the power of conveying electricity from place to place; or, as we would say, of conducting it. He also observed the crackling and snapping of the electric discharge which had previously been noticed by Dr. Wall. He made the prophetic observation that "though these effects are at present only minute, it is probable that in time there may be found out a way to collect a greater quantity of the electric fire, and, con-

sequently, to increase the force of that power which, by several of those experiments, if we are permitted to compare great things with small, seems to be of the same nature with that of thunder and lightning."

No truer prophecy was ever made, for none of Nature's forces has seen such development within the last hundred years as Electricity.

Stephen Gray experimented chiefly between the years 1720 and 1735. He was contemporary with M. Dufay of France, who about the same time enunciated the fact that there were two kinds of electricity. He gave the name of "vitreous electricity" to that produced from glass; and the name of "resinous electricity" to that produced by exciting resinous bodies.

The foregoing discoveries destroyed the inertia of the German and Dutch philosophers, and roused them to activity. As a result, we have to chronicle the improvement by Professor Boze of the crude electrical machine used by Newton; the application of a friction cushion to the machine, by Winckler of Leipsic, and several other brilliant experiments and discoveries. These, however, were all overshadowed by the discovery of a method of accumulating and preserving electricity, though, it might be incidentally remarked, there are almost as many claimants to this discovery as there are authors of "Beautiful Snow," or inventors of the Telephone. But, so far as careful research shows, this discovery was first made by a German ecclesiastic named Kleist, who lived in Cammin, in Pomerania, and who announced his discovery in a letter addressed in No-

vember, 1745, to Dr. Lieberkühn of Berlin. He partly filled a phial with some conducting liquid and drove a nail through the cork till it dipped in the liquid. On electrifying the nail he found that if he touched the nail with one hand while holding the phial with the other he received a powerful shock; showing that the conducting substance absorbed electricity.

Early in the following year the same discovery was made accidentally by Cuneus of Leyden, a student of Professor Muschenbrœck. Muschenbrœck himself assisted in the perfection of this discovery, and, as he and Cuneus correctly stated the conditions necessary to the success of the experiment, the discovery has always been named the "Leyden jar," or phial.

Sir William Watson made important experiments about the year 1745, and gave the Leyden jar its present form. He, at the head of a party of the Royal Society, made an exhaustive series of experiments on electricity, and, among other results, discovered that an electrical circuit could be completed through the earth, thus ante-dating the present earth-circuit by about a hundred years.

The most eminent electrician of the period between 1706 and 1790 was decidedly Benjamin Franklin, who presented, in a distinct form, the theory of positive and negative electricity, proved the identity of electricity and lightning, and, by the clearness and vigor of his writings, did much to make the study popular.

John Canton, an Englishman, next discovered that the terms used by Dufay were erroneous and mislead-

ing, and that both kinds of electricity might be developed from the same substances, by changing the quality of the rubber, or altering the surface of the material to be rubbed.

In 1771, Cavendish found that iron conducts four hundred million times as well as distilled water, and was the first person to produce water by exploding together oxygen and hydrogen.

At the same time, Coulomb flourished and was one of the most eminent philosophers of the last century. He invented an instrument called a "torsion balance," which is still much used in the measurement of electrical action.

All these experiments were, however, in the department of frictional electricity. But a new form of the force was now to be developed; and in 1780 the fact that Galvani had frogs for dinner revolutionized the science by exhibiting to him the muscular contraction of the frog, when two dissimilar metals came into contact with each other and the frog simultaneously. This led to the invention of the battery by Volta in 1800, and created a new era in the science. The chemical effects of the voltaic battery soon proved to be far superior to those caused by frictional electricity; and voltaic electricity now absorbed the attention of the experimental philosopher.

In 1820–21 Professor Oersted of Copenhagen discovered that a current passed through a wire in the vicinity of a magnetic needle, had the power to deflect the needle. Upon this discovery the entire superstructure of electromagnetic science is based.

A French philosopher, Ampère, explained this fact, and at the same time explained the relationship of electricity and magnetism by the hypothesis, that "Magnetism is the circulation of electrical currents, at right angles to the axis joining the two poles of the magnet."

In 1820, Arago and Davy discovered the power of the electrical current to magnetize iron and steel; and in 1825, William Sturgeon, of London, utilized the discovery by constructing the first electro-magnet. He, however, put the cart before the horse, by insulating the core, and then winding it with bare wire, which of course had to be loosely wound, so that the convolutions would not touch each other. Professor Joseph Henry, in 1829, improved this so wonderfully, by winding a soft iron core with covered wire, as to be really the creator of the electro-magnet, and the ancestor of the Morse Telegraph, which was shortly to follow. A German named Seebeck, discovered thermo-electricity in 1822, and Sir William Thomson made many experiments in the same branch.

Faraday has, however, been one of the most brilliant experimenters of the present century, and, commencing in 1831, did not cease until his death. He discovered that a current in one wire induced another in a wire in its vicinity; and called the discovery dynamic induction. He discovered magneto-electric induction, or the development of electrical currents, by the movements of a magnet. By comparison, he showed that statical, voltaic, magneto, thermo, and animal elec-

tricity were identical, being but different phases of the same force.

Magneto-electricity has been largely employed in the arts. It has been utilized in printing and telegraphy, and has just reached its culminating point in the machines of Gramme, Brush, and Siemens and Alteneck, which have completed a genuine revolution in electric lighting. Magneto and dynamic induction combine to produce the Ruhmkorff Intensity Coil or Inductorium, which has been and must ever be of great use to the physicist.

Dr. G. S. Ohm, in 1827, rendered a great service to the science by proving and publishing the mathematical laws of the electric current. These laws, which form the very groundwork of electrical science, have been since supplemented by Kohlrausch and Kirchoff, and rendered practically useful by the application of the galvanometer. This instrument was first invented by Schweigger in 1820, and has been improved and modified in many ways and by many persons, last but not least of whom is Sir William Thomson, whose delicate indicating galvanometer has been found indispensable in interpreting the feeble currents of submarine cables.

In 1836, the Daniell battery was invented, and still maintains its credit as the most constant battery in use. It was speedily followed by the invention of Grove, whose well known battery, so long used as a main battery on American lines, far surpassed Daniell's in smallness of internal resistance, and in electro-motive force; while, on the other hand, it is more troublesome

to manage, and emits noxious fumes. The gravity forms of the Daniell battery are legion in number, and one type, the "Callaud," is now used on most of the American telegraph lines.

In 1837, Cooke and Wheatstone established the needle telegraph in England, where it is still used; though on most lines it has been superseded by the "Sounder."

The Morse telegraph was also introduced in 1837, but was not put into practical use until 1844. It is still the main resource of the telegraphs of this country, and has been widely spread in nearly every country on the face of the earth. The first repeater was the button, invented and applied in 1846, at Auburn, N. Y. Since then, Bulkley, Farmer and Woodman, Hicks, Milliken, Bunnell, Catlin, and many others have invented repeaters; and indeed, up to the time when Stearns perfected the duplex, every young operator, as soon as he could rush thirty words per minute, conceived it his duty forthwith to invent a repeater. Since that era, the duplex has succeeded it in that department of invention.

Simultaneous transmission in different directions, first attempted by Gintl in 1853, was fifteen years after practically accomplished by Joseph Stearns of Boston; and, in 1874, the quadruplex was invented by Edison; but did not become a practical institution until perfected by Gerritt Smith in 1875.

It would seem now as if the limit of man's invention had been reached; but, in 1876, vocal sounds were

transmitted by Alexander G. Bell, with what result we all know.

The years 1877 and 1878 saw rapid progress in the introduction of the telephone as a communicating medium, and many improvements in telephony were made.

In 1877, Berliner and Edison invented the battery telephones, which produced electrical undulations corresponding in form to the sound waves transmitted by varying resistance in a battery circuit. The changes in the strength of current were by this process much greater than those produced in the magneto-telephone, and the volume of the sounds reproduced was of course correspondingly amplified.

Numberless improvements, of greater or less value, have, from 1876 to 1882, been made in every branch of telephony, by Gray, Edison, Bell, Berliner, Blake, Irwin and many lesser lights.

The electric light has, also, within the last five years, experienced a wonderful development, and, in the hands of Brush, Wallace, Farmer, Siemens, Weston, Maxim, Edison, Sawyer, Jablochkoff, Werdermann, and Swan, seems likely to work a complete revolution in the art of illumination. Arc, incandescent and candle electric lights have alike participated in and mutually aided this extraordinary advance; and at present there is scarcely a city of importance in the United States which has not its electric light company.

Electricity has also been applied to locomotion with a considerable degree of success, by Werner Siemens, of Germany, and by Thomas A. Edison, of New York.

Mr. C. W. Siemens has turned his attention to horticulture, and utilizes the electric light to accelerate the growth and to improve the quality of fruit and flowers, by turning night into day, and permitting the work of ripening to be carried on at the rate of twenty-four hours to the day, instead of twelve as heretofore. He has shown, too, that electricity may be profitably employed for the rapid fusion of the most refractory metals.

It has also been demonstrated that articulate speech may be readily transmitted without wires, employing only a ray of light as the medium of communication, by means of the use of selenium under suitable conditions.

The latest idea is that of transferring scenes by electricity, but this is as yet nothing but an idea; yet, after what we have seen, we cannot but regard it as something which must sooner or later be realized.

FACTS AND FIGURES ABOUT THE SPEAKING TELEPHONE.

The first record of a sound transmitting instrument in connection with which the word "Telephone" occurs, is believed to be the descriptions in contemporary publications of Wheatstone's exhibition of the transmission of musical vibrations through wooden rods. This as early as 1821 was entitled a "Telephone Concert."

In the succeeding year, the much quoted telephone of Philip Reis was produced and experimented with; melodies and musical sounds were reproduced by it with great exactness, and, subsequently, when the instrument was brought out in an improved form, even articulate sounds and words were transmitted, received and understood by those who knew beforehand what the words were going to be.

But between this telephone and the present speaking telephone there was a great gulf, as wide as the gulf which, in the parable, separated Dives and Lazarus. This gulf was bridged by the discovery made by A. Graham Bell that to accomplish the successful reproduction of articulate speech, electrically, it was necessary that there should be no interruption of the circuit, and that the current should be made to undulate, in exact response to the sound waves produced by the voice; and the invention of apparatus in which his discovery was practically embodied. Mr. Bell's conception

of his invention dates back certainly as far as 1874, and by March, 1876, the celebrated patent which has been the text of so much litigation and so many interferences, was issued.

The exhibition of the instrument at the Centennial Exhibition, and the glowing and graphic reports of the judges, Sir William Thomson and Prof. Henry, gave the invention and the inventor a world-wide fame, and from that time onward the whole community, scientific and unscientific, journals of news and journals of science, united in echoing and re-echoing the wonderful tidings that Mr. Bell had accomplished an unheard of and unparalleled feat in electrical transmission. He worked hard to introduce his invention by public exhibitions and lectures throughout New England and the Eastern States, and success finally crowned the efforts of his associates and himself.

It is a matter of public history that the first telephone line was constructed early in 1877, between the house, at Somerville, and the office, at Boston, of Charles Williams, Jr. This was soon followed by others, and before the end of May, 1877, a practical telephone exchange was operated in Boston by Mr. E. T. Holmes upon his burglar alarm wires. This was the beginning of the Telephone Central Office System, the lines of which have now stretched forth through all the earth.

The wonderful impetus which the telephone has given to invention is evidenced by the immense increase in the number of electrical patents issued since 1876. In that year but one patent came out on the telephone,

or telephonic telegraphy; namely, that of Bell. In 1877, the telephonic patents issued increased in number to three, the first being another one to Bell, and the other two being modifications thereof, both invented by J. J. McTighe of Pittsburgh. In 1878, another increase was made and the number of patents issued for telephones amounted to twenty-five, the inventors being Dolbear, Berliner, Trowbridge, Smith, Bell, Edison, Gower, Richmond, Gillet, Gray, Irwin, and Phelps. In the same year also was introduced the battery transmitter, both of the Edison and Blake types. In 1879, the number of patents for telephones and improvements thereon increased to thirty-two. In 1880, sixty-nine patents were issued for improvements in magneto and battery telephones, and in 1881 the number amounted to seventy-seven.

It must not be supposed that half of these are practical working instruments. Some of them are but improvements in parts, or new ways of putting parts together; while many more are fearful and wonderful methods of putting the said parts together. Besides all these, there have been many improvements in signaling apparatus, call bells, switch-boards, circuit arrangements and exchange systems; while the photophone has some three or four numbers of its own. The figures given afford us some insight into the interest displayed by inventors generally in the art of telephony; and it may be safely stated that at least one-third as many more applications for patents have been rejected by the dictum of the examiner.

The telephone has been applied to many purposes,

Though mainly utilized for the transmission of speech between distant points, it is equally convenient for use between different rooms of a house, as a speaking tube; or in mines, to keep the laborer, groping in the bowels of the earth, in intimate communication with his fellows on the surface. Placed at the business end of a burglar alarm line protecting a bank or similar place, the telephone, in the form of the Blake transmitter, is made to give us knowledge of the marauder's every movement. Connected in derived circuit from the main wire of an electric light machine, no instrument could serve better the purpose of ascertaining the relative steadiness or unsteadiness of the current. And as a current measurer or detector, its sensitiveness is unequaled by the finest galvanometer, since it makes evident the faintest current or the slightest change in a current.

HOW TO BUILD A SHORT TELEGRAPH OR TELEPHONE LINE.

In almost every scientific or technical newspaper may be seen inquiries from amateurs relating to the building of short Morse telegraph or telephone lines. As such a line, well constructed, is a social convenience of no ordinary merit, besides being a harmless and instructive source of amusement to the youthful mind, when philosophically inclined, this opportunity is taken to give general directions for the proper construction of such a line.

Notwithstanding the extraordinary growth and popular character of the telephone as a means of electrical communication, it is found that the Morse key and sounder hold their own on amateur lines, especially in the rural districts; chiefly because the very mystery about telegraphs, the fact that it must be deeply studied to be understood, has a veritable charm about it that the telephone, speaking as good English as we do ourselves, can never for that very reason have.

It is therefore proposed to describe the connection and arrangement of a set of Morse telegraph instruments before proceeding to the telephone and its concomitant apparatus. Three essential elements are requisite in the simplest line of telegraph, namely: The apparatus for generating or developing the electricity; the line or conductor, whereby the electricity is transferred from one point to another and communication established; and the transmitting and receiving appara-

tus, by which the electrical messenger makes itself apparent and forwards and interprets its language. Let us first consider the generator, whereby the electric force is developed to operate the Morse line. Although there are many ways of generating electricity, for the purpose in hand the simplest apparatus is a galvanic battery. The usual arrangement in this country being to keep the battery on closed circuit, it is necessary to choose one that does not soon exhaust itself when its circuit is closed. It is also well to adopt one that is economical in maintenance, and that does not need much attention.

Such a one may be made as follows: Take as many glass jars as are necessary, in size six inches wide by eight deep. Take also a corresponding number of round flat plates or sheets of copper, that will easily go in and lie on the bottom of the glass jars. Then cut a number of pieces of gutta percha covered or kerite copper wire. Bare one end of each piece for about an inch and rivet (not solder) it into a couple of holes previously drilled in the copper plates near the edge. The wire must now be extended up the side of the jar, to make connection with the next zinc.

All the coppers, being placed inside and at the bottom of the glass jars, are now covered with sulphate of copper (blue vitriol), crushed to about the size of a small filbert. The layer of copper sulphate may be three inches deep, and is to be covered first with a piece of cloth or blotting paper, cut to fit the jar; the blotting paper must then be covered with a layer of fine

sawdust, packed down rather firm—while on the top of the sawdust is placed the plate of zinc. The cell may then be filled up with water, and when put in operation the cells used are connected in series, the zinc of one being connected to the copper of the next, and so on. The battery, when first set up, will not produce much current, and so should be set up several days before it is required, and placed on short circuit—each cell connected to the next—and a copper wire then connected from the zinc at one end to the copper at the other.

Acid batteries may of course be used, if preferred, but they are not recommended for various reasons. They emit gases which are deleterious to health; they require much attention and great care in handling the solutions, while they are, moreover, expensive and rapidly consume their materials. Information regarding them can be procured from nearly any good electrical text-book.

The conducting medium is next to be considered. For long lines, No. 8 or 9 galvanized iron wire is generally used, strung on large glass insulators; but for a short private line, No. 12 or 14 is sufficiently large. It is not advisable to use a smaller size for telegraph lines, because the smaller the line the harder it is to insulate properly; but for telephone lines which are not of any great length, No. 18 or 20 iron or steel wire will be found to work wonderfully well, and the greater ease with which it is handled commends it to the inexperienced.

The Ansonia Brass and Copper Company supplies a

first-class brand of hard and strong copper wire, which is very suitable for either class of line.

These smaller wires may be bound with tie wires to what are called pony insulators, which can be procured at small cost from any dealer in telegraph supplies.

A telephone wire, which is not so thoroughly dependent on good insulation, may be strung on porcelain knobs.

The necessary transmitting and receiving instruments for a line of telegraph, are a key and sounder at each station.

The line may have a station only at its two ends, or it may have any number of intermediate stations.

We will, in order that both "way" (intermediate) and terminal connections may be explained, describe a line of three stations, one at each end and one in the middle. The supposed line is, for example, one mile in length. It is not necessary to erect poles at every point where the wires are to be supported; although when this is done the line is more exclusively under the control of the builder at all times.

The poles necessary to carry one wire need not be more than twenty-five feet long. They should be planted not less than three and a half feet deep, and must not be less than three inches in diameter at the top. At road crossings the poles must be sufficiently high to clear anything liable to pass under them.

The line wire is supported on glass insulators, which are screwed on to wooden brackets, and which in their

turn are spiked to the side of the pole, near the top. If poles are not used, the ridge-poles of houses or barns can frequently be utilized, the insulator in that case being fastened on what is called a ridge-pole iron. Irons can also be fastened on the corners of chimneys for the reception of insulators.

After the supports are all in place, the wire, which for a such a line should not be larger than No. 12, may be strung. It may be pulled up very tight if the work be done in cold weather, and reasonably tight in any case.

At each station where the line wire enters, a hook or other insulator must be fastened to the wall just above the window, and after the line wire is strung, it should be brought down to the window, and there terminated, by winding it round the insulator tightly, and then winding it back on itself.

A hole must then be bored through the window frame and a rubber covered wire passed through. About six inches of the outside end must be stripped and carefully scraped until clean and bright. The iron line wire must also be scraped or filed bright for about four inches on the outside of the last insulator, which we suppose is just above the window, and the end of the covered wire is tightly and closely bound round the scraped portion of the iron wire. The joint should then be soldered—indeed, every joint ought to be soldered.

The end of the rubber-covered wire which is inside of the window is also stripped, and is spliced carefully

to a piece of office wire, preferably No. 18, covered with braided cotton. This wire is either tacked down with double-pointed tacks to the window frames or partitions and walls, until it reaches the instrument table, or strung on porcelain picture knobs. The latter plan is the best for plaster walls, and, indeed, in nearly every case, as it gives a choice of route, enabling the constructor to take the ceiling if he desires. On arriving at the instrument table, the wire should be carried down behind it and brought up through holes in the table, which we shall hereafter designate.

After the line and office wires are run, the ground wire should be constructed, and its end brought also near to the table or instrument stand. It may be here said that if the line is less than a quarter of a mile long, it is far better and more reliable to run a return wire than to complete the circuit through the earth. For a ground wire at a terminal station, a water or gas pipe should be used, if possible. The pipe should be filed clean and bright at a point outside of the meter, for a surface of at least two inches. A piece of bare copper wire, of No. 18 or 20 gauge, and about four feet long, should then be taken and coiled tightly and smoothly round the pipe, and an end about six inches long left, which may be spliced to the wire leading from the battery. The ground connection should in all cases be soldered. If a pipe cannot be obtained, a hole must be dug until the earth, which is always damp, is reached, and a plate of iron, to which the wire from the key is attached, must be buried in it. It is not well tc

ground on a plate of one metal at one end and another metal at the other, as currents are then set up on the line.

If the line is one mile long, of No. 12 wire, with stations only at the two ends, the sounders should be about sixteen or twenty ohms resistance each, and seven cells of battery may be tried, the number to be increased if necessary. If the line is but half a mile long, the sounders need only be from eight to ten ohms resistance. While if it is two miles long, they should be thirty-five ohms.

The battery may be all at one end of the line, or half may, if desired, be placed at one end and half at the other. For such a short line, it is preferable to have it all at one place.

Lightning arresters, which can be procured ready made from any instrument maker, should be placed at each station between the window and the instruments.

In choosing a table for the instruments, it is best to take an ordinary table or desk of unpainted wood. A table covered with green painted cloth or enameled cloth should be avoided, or, if used, a place should be cut out for the key, so the key does not touch the painted surface at any point. Such a table, when left as it is and the key placed over the enameled surface, often causes an escape which, if unsuspected, is hard to find. The table need not be large. The sounder should be placed at the left hand side, and the key at the right, so as to be readily accessible to the right hand of the

operator. The instruments should also be placed at the inner side of the table, in order that the operator's arm may obtain a rest while sending.

After the sounder is placed in the required position, it is screwed down, both to retain it in position and to give a solid sound; and a hole is bored through the table at each end of the sounder binding posts. Larger holes are bored for the legs of the key, which is then placed in its proper position and also screwed down.

The office wire attached, the kerite is led under the table, and brought up through one of the holes opposite the sounder; the covering stripped off and the end doubled on itself and inserted in one of the sounder binding posts. A short wire, also covered, is led from the other sounder binding post to one of the legs of the key, under the table; while from the other leg of the key a covered wire is run down the wall and continued to one pole of the battery; that is, either to the zinc or copper of one of the end cells of the series. If the wire from the key is connected with the zinc, which is best, the other cells must all be connected together as before described, and the cell at the other end connected by a wire to the ground.

When the battery is divided, part being located at one station and part at another, opposite poles must be to line. That is, if at one station the copper pole is connected with the ground and the zinc with the line, at the other station the connections must be reversed, the zinc being to earth and the copper to line.

It must be understood that when, as in the majority

of cases, the battery is all at one place, the wire at the other terminal station must be run directly from the key to earth, the line of circuit then being from the ground at station 1 to the copper pole of the battery, through the battery, from the zinc pole of the battery to one leg of the key, from the other leg of the key to the sounder, thence to line, out to station 2, to sounder, key and ground. No relays nor switch will be required.

At the intermediate or way station, the wire of course goes both into the station and out again, entering the sounder magnet, from it being led to the key, and from the key to the out-going line wire.

A very convenient and economical short line may be built on the "open circuit" or British plan. On this plan a battery is placed at each station. At each end station, the line is permanently attached to the main stem of the key, which may be a very cheap concern, consisting only of a simple strap of metal with a knob handle, a back contact or limit, connecting through the sounder with the earth, and a front contact or anvil, connecting through the battery with the earth. The battery at each station may have similar poles to line, as then it is easy to tell when the other station attempts to interrupt when No. 1 is sending. Leclanché batteries answer very well for an open circuit line. Connect, as already indicated, the key at each terminal station with the line wire; one pole of the battery to the ground, and the other pole to the front contact or anvil of the key; one of the sounder binding posts to

the back contact of the key, and the other to the ground wire.

At the intermediate station, fix the key and sounder in their respective places, then connect the line "in" with the main body of the key, and the line "out" with one of the sounder binding screws; connect also the same sounder screw with one pole of the battery, and the other sounder screw with the back limit or contact of the key, and the other pole of the battery with the front contact or anvil of the key, and the line is complete.

Each station, it will be seen, works by its own battery altogether, and the line when at rest is complete but has no battery on it; the battery being only consumed while its own station is sending. On a line like this the sounder of the sending station is not in a position to respond to the sending of its own key.

Now, to transform the above described line to a telephone line, if the batteries are already on hand it is well to retain them for signaling purposes; otherwise it would be most satisfactory to procure a set of magneto bells from the same agent who supplies the telephones. The connections are very simple. The line, commencing at the earth station No. 1, passes through a small single stroke bell, then to the back contact or resting point of a metal strap key. The line entering the station is led to the button of an ordinary two point button switch; a wire led from one point to the strap key, and from the other point of the switch to one of the two right hand binding screws of the Blake

transmitter; the other right hand screw of the transmitter is to be connected by wire to the telephone, and the telephone to the ground wire. A battery of sufficient strength is then attached to the key anvil. The line, after leaving station No. 1, enters the way station No. 2, passes through the button switch to the strap key, through the back contact to the signal bell, thence out to station No. 3. The telephone branch at the way station is connected on one side of the instruments with the other point of the button switch as before, and on the other side of the telephone with the line wire going out to station No. 3, instead of to the ground.

The battery branch also is attached at one pole to the out line wire, and at the other pole to the key anvil.

Arriving at station 3, and entering the button switch, the connections are then made precisely as in station No. 1. The transmitter batteries may be one cell of Leclanché, and must be provided with a circuit breaking switch, so that their circuit will only be closed while being used.

To operate this line, we will suppose that No. 1 wants to talk with No. 3. He presses his key, and thus disconnects his bell, and at the same time connects his battery to the line, sending the signal through the bell of No. 3, who replies by pressing his key and causing the bell of No. 1 to ring. Both parties then turn their button switches on to the telephone branch, and may converse.

All signals, of course, pass through the bell of No. 2, and consequently it will be necessary to arrange a code of signals, one for each station.

A line built according to the foregoing description will be found to work very satisfactorily.

THE EARTH AND ITS RELATION TO TELEPHONIC SYSTEMS OF COMMUNICATION.

Filling the most important sphere in the realm of electrical communication is, perhaps, the earth. We in America in this connection usually say the "ground"; yet there is no question but that the "earth" is both the most proper and the most comprehensive term to apply to this invaluable auxiliary.

No second place can be assigned to the earth, as a feature of our present telephone system. It is indeed the base, the groundwork, the very foundation upon which the entire superincumbent mass of telegraphy and telephony is erected. If we run a line two miles long, or twenty miles long, it is essential that a complete circuit shall be made before work can be done—before we can converse over it. What shall we do? Shall we construct a second wire from the end of our line back to the starting point, and join the two ends together through the instrument? Such a plan works well, but the most inexperienced person can readily see that twice the line means twice the cost. A cheap substitute offers itself; one that costs nothing and does its work on a moderately long line better even than a second wire, and one, moreover, that if properly applied at first needs no further attention. That substitute is the earth, though not every telephone exchange manager credits the universal mother with the construction account thus saved.

When our lines are all completed and our switch-

board is being set up, what is to become of the office end of perhaps a thousand lines, all of them safely connected to the earth at the outer end? Again we connect to earth and, strange to say, we may if we please connect the whole of our thousand lines to one earth wire, without any apparent embarrassment or interference one with the other, except under certain conditions.

We find by sad experience that if we provide no means of prevention, the lightning will run into our offices and houses by means of the wires intended solely for electricity of a gentler nature, and will burn up as a parched scroll our bells, our telephones and our annunciators. What is to be done? We attach between our delicate instruments and the lines lightning arresters, and connect these arresters to the *earth.*

Some of us, still harassed by that effete bugbear, the notion that everybody is interested in, and wants to hear, what we say over our telephone lines, must of necessity, to preserve ourselves from that dreaded contingency, use what is popularly known as the "secrecy switch," which consists, as every one does not know, of an arrangement of wires and springs which open the line on the side toward which you don't want to talk, connecting the broken fragment attached to your telephone to—what? To the wire leading from the earth.

When a line breaks, an inspector issues forth to find the trouble. He arms himself with a piece of magnet wire, and after locating his trouble between two stations, proceeds to connect the magnet wire to the binding

screw of the bell at the station next to the break toward the central office, so as to make at that station a temporary terminal. Cutting the station into circuit, to what does he connect the other end of his magnet wire? Again to the earth.

Two subscribers' lines are connected at the central office for conversation, and the supervising operator wants to know that they get connected all right, also to know when they finish, for in the telephone business time is money. What is to be done? Here, no doubt, the best way is to loop in listening and transmitting telephones, by means of a double cord, a wedge and a spring-jack, or other kindred devices. With the appliances found in many exchanges, especially the smaller ones, it is, however, often impracticable to do this. As an alternative, we can attach one bar in our switch to a wire, run that wire to our telephones and from them to the earth, thus forming a third leg to the two circuits already in communication, making an arrangement somewhat resembling the celebrated three-cornered duel of Mr. Midshipman Easy. This is found to work well when the circuits connected are both short.

One more genus of earth connection is worth noticing in this relation, and that is the "accidental"—the ground that comes on a circuit in the still hour of night, "when churchyards yawn," etc. No trouble is more annoying than the "ground" or "escape," and its most remarkable property is the wonderful facility and perfection with which the earth connection is made in such cases. No inspector, office manager or trouble

lineman can have failed to notice the ease with which such a ground forms itself, and perhaps to have contrasted with it the infinite trouble and difficulty he has experienced in making a good and reliable legitimate ground in its legitimate place. We see, therefore, that the earth, besides assisting us in our construction, occasionally throws in a little volunteer business on its own account, to remind us, as it were, of the services it ordinarily renders. It will, therefore, do none of us any harm, and perhaps some of us a little good, to cast an eye over the several uses of the ground wire, to see if we make the best use that we may of its benefits, and if possible to improve its facilities.

Let none of our telegraph and telephone experts, possessed of "every implement and means of art, and twenty years' apprenticeship to boot," despise the day of small things, and conclude that because *they* know all that is written here, and a great deal more beside, time and space are therefore thrown away. The object of this and similar articles is to furnish popular instruction for the thousands of the rank and file of our telephone men of to-day; the men who have to do the work, and who have had no chance to obtain either twenty years' or even twenty months' apprenticeship at electrical work. Many exchange managers and superintendents, also, have had no previous experience in the line they are now in, and will gladly hail even a small portion of the leaven which it is hoped will by and by leaven the whole lump.

The terminal ground will be first considered.

We have built our line. We are now connecting our bell and telephone, and the lineman, who has come from his last place with powerful recommendations, runs a light copper wire from the last binding screw of the bell to a lacquered bronze gas fixture, twists the wire, bared for three or four inches but not scraped, round the pipe once or twice, and leaves it. The telephone works, as what telephone will not; but it is in spite of the "ground," not in virtue of it. The manager, who has, we suppose, seen fire, wonders why it takes so much battery to work that line. He has all he can do to attend to the complaints of the unfortunate subscribers; but at length finds time to take a trip over the line himself, as he, out of the depth of his sad experience, suspects a bad connection. He passes along from station to station, coming in due course to the end, where, after two minutes' scrutiny, he perceives the source of the trouble. He remedies it in the following manner: Sending for his lineman, he will have a stout wire run to the nearest *water* pipe. The water pipe, which we will hope for its own sake is iron (lead should never be used), is then filed or scraped clean and bright for at least two inches laterally, and a No. 16 or 18 copper wire scraped bright, and having a length of at least six feet, is carefully and tightly wrapped around the scraped portion of the pipe, each convolution close to the preceding one, until the whole of the brightened surface of the pipe is covered. The wire should be passed under several of the last convolutions, so as to pull tight, and enough left at the end, say eight inches, to make a

good splice. This end is then spliced to the wire leading from the instrument; and for the first time in the life of our line it enjoys a good earth connection.

If both gas and water pipes are available, connect to both. Water, however, is always to be preferred to gas, for the reason that gas-pipe joints are made up in red and white lead, which act as insulators, and resist the passage of the current. If gas-pipe be used, the ground connection must be made between the meter and the street. Water pipes are not open to this objection, because, being filled with water, there is always a pretty good conductor inside of them to allow the current to pass the joints.

Some prefer, instead of the connection just described (which, by the way, our experienced manager carefully solders before leaving), a screw clamp with a binding post for the reception of the wire. This is screwed tightly to the brightened pipe. We do not, however, advocate it, knowing the inveterate propensity of binding screws to work loose.

If our manager can find neither gas nor water pipe, he looks for the pipes attached to a steam heater, and tries them. Very often they make an excellent ground. Very often again they do not.

But he has now finished the job and returns to the office—his man, if he is the right kind, knowing how to manage in future, and if he is the wrong kind, thinking to himself: What a heap of trouble and work thrown away!

A rather singular case of moral obliquity, which oc-

curred some months ago, may be mentioned here, as showing how the plainest instructions can be readily misunderstood.

A new telephone exchange had been started in a small city, and the expert from an adjoining place had been over, and instructed the new telephonists in the rudiments. Among his other instructions, he said: "If you have to make a ground where there are no pipes, you must dig till you get to damp ground, and there bury a plate or rod." The line was built but would n't work. You could talk over it, but you couldn't ring over it. An inspector visited the exchange and was appealed to, in most pathetic terms, to make the line work.

Inquiring concerning the nature of the ground, he was told that the ground wire was certainly perfect; that they had dug a deep hole, and then driven into that a twelve-foot rod, and that they had filled it with water; but still the line would not work. The inspector went, however, to look at the terminal. Taking the ground wire from the binding screw, he found that he could taste the current quite strong. He then went to see the ground, and found that a new way had been discovered. The twelve-foot rod turned out to be a pipe with a water-tight cap screwed on the lower end. They had, as they said, dug a hole and then driven the pipe in, but the ground was dry and rocky. To finish the job, then, they had brought water and carefully *filled the water-tight pipe.*

Coming now to our central office ground connections,

we will uniformly get the best results by attaching the ends of our circuits to a No. 4 or 6 copper wire, carefully cleaned, and soldering every connection. This large copper wire must be connected by as many routes to earth as possible, using invariably as much surface as can be, so as to reduce the resistance of the ground. That is, connecting all our large wires to which the circuits are attached to one still larger, that, in turn, should be branched off; one branch fastened by about six inches of convolution to the water pipe, and soldered; another similarly attached to the gas pipe; another, perhaps, to the steam pipe; another to the building itself, if it be iron, and so on.

The foregoing remarks apply equally to the lightning arrester ground wire, which should be made of the largest copper wire that can be procured.

In this connection it is, perhaps, well to describe an experiment which is often tried, but which, by the very nature of things, can never succeed. It is, briefly, to loop an electro-magnet into the common ground wire, so that at night, or in cases where an operator cannot give the exchange his entire attention, when a call came in on any circuit, this magnet should attract its armature, and ring a local bell. Any practical electrician will at once see that, owing to the infinitely small joint resistance of the combined circuits uniting in the ground wire, no signaling instrument can be expected to work when so placed. To the amateur, however, the idea appears so promising that he must try it himself before he will be satisfied that it is impracticable.

The earth wire at an intermediate station on a telephone line should never be dispensed with. It should be used in connection with a local lightning arrester; and wherever the secrecy switch is used, the same wire may be utilized to work it. It may be constructed in the same general way as the ground at a terminal station, but is not so important, inasmuch as in this case only one individual is concerned, and in a terminal station the entire line is interested.

In the case of a temporary ground wire used to complete the line circuit on one side of a break, no particular care is necessary. Several turns around a brightened gas or water fixture will usually answer very well to work with, until the omnipresent wire fiend repairs the line.

Coming now to the listening ground, it has been found that when two short lines are connected through the central office for conversation, it is not always necessary to insert the instruments of the controlling operator into the circuit, but that the necessary work can be done by tapping the said lines with telephones connected with an earth branch.

This works well, when the lines are both short; but if they are long, or especially if one is short and the other long, the ground branch is found to carry away too much of the current, and the conversation becomes indistinct.

If under such circumstances it be still found impossible to loop the instruments, a coil without a core, or some other high resistance, should be inserted in the

circuit of the ground branch as an equalizer—as high as 10,000 ohms will do no harm. A bottle of distilled water, hermetically sealed, placed in the ground branch circuit, and connected by wires from either side, answers very well.

The "trouble" ground needs a separate chapter to do it justice.

When several trunk lines are used for the operation of telephones between two trunk stations, such, for example, as two cities, they should each, if possible, terminate at a different ground; because when they all run to the same ground, conversation transmitted on one wire often leaks over the ground wire and returns on the other lines, thus being one cause of what is popularly, but often in a great measure erroneously, known as "induction."

Moreover, it is well to shun a ground terminal which may be within two hundred feet of the ground terminal of an electric light wire.

As a long metre doxology whereby this chapter may be fittingly concluded, we repeat once more that, in all cases and at all times, too much care cannot be taken, or too many precautions employed, to make a ground connection perfect.

"There is no speech nor language where their voice is not heard."

THE MAGNETO-TELEPHONE—WHAT IT IS, HOW IT IS MADE, AND HOW IT SHOULD BE HANDLED.

The electrical transmission of articulate speech depends upon the development of currents of gently varying rise and fall in the conductor connecting any two points, and which also rise and fall correspondingly in form to the sound waves caused by speech at the transmitting end of the line. Sometimes, as in the case of a battery transmitter, these variations are produced in a current by the variation of the resistance of the circuit. Other times, as when the magneto-telephone is used as a transmitter, the varying or undulating currents are produced by the variation of the electro-motive force; or, in other words, by varying the power. The transmission of electric vibrations corresponding in form to the sound waves, in the manner last named, as also the reproduction of similar sounds in a magneto receiving telephone, depends upon the principles of magneto-electric induction.

As there are hundreds of the ordinary Bell telephones in use for every one of any other make, that pattern will be the one described and discussed in this chapter.

If a current of electricity flowing in a circuit be allowed to flow steadily without interruption or reversal, it may be called "a steady current," and may be employed to maintain a uniform degree of magnetism

in an electro-magnet, to produce a light and for many purposes too numerous even for casual mention.

If a current flowing in a circuit be rapidly interrupted, as, for example, that of a primary circuit of a shocking machine, a Ruhmkorff induction coil or the circuit in which an ordinary vibrating bell may be working, the resulting current or currents will be intermittent, and if the vibrations are sufficiently rapid a musical tone will be produced. Such currents are known as intermittent currents.

If in a continuous circuit the strength of current flowing be suddenly increased or diminished, but without breaking the circuit, another system of electrical pulsation is produced. This also may be made to produce musical or other sounds; but still speech cannot be transmitted. Such currents are called "pulsatory currents," and are exemplified in the well known quadruplex, where a continuously closed circuit has more or less battery supplied to it by different positions of the key; or by the "Wilson" duplex, in which a resistance is by the action of the key alternately thrown into and out of circuit, thus decreasing and increasing the current strength and producing signals.

If, finally in a continuously closed circuit, an electric current be flowing, and its strength be alternately *gradually* and yet very rapidly increased and diminished, so that the impulses of current may be graphically represented by a regular curve of wave-like form, we have still another system of current, which is now universally known as "the undulatory current." It is

sometimes produced by giving gradual but rapidly recurring changes of strength to a steady current of continuous and uniform direction; in which case it is graphically represented as a sinusoidal curve undulating regularly either above or below a horizontal line.

It is also produced by gradual and rapid changes of both strength and direction, and is then represented as a similar curve undulating alternately above and below the horizontal line.

It is the undulatory current which renders the transmission and reproduction of articulate sounds possible, because by its employment the pitch, the timbre or quality, and the amplitude of tones can be produced at a distance.

The telephone is the instrument by which the undulatory current is utilized and made apparent, and the name simply means an apparatus by which sound is conveyed to or reproduced at a distance.

The currents generated in the telephone are produced on the well-established principle that when a coil of insulated wire is fixed upon or surrounds a soft iron core of a permanent magnet, or upon the end of a magnetic bar, any alteration in the distance of an armature placed in front of the core, alters its magnetism and produces a current in the coil. In the case of a magneto-telephone, the armature is represented by the diaphragm.

Sound, it is well known, is the sensation produced in the ear when it is affected by undulations of the atmosphere, and these undulations of the air, producing the

sensation of sound, are themselves usually excited by the vibrations of the sounding body which set the air in motion producing waves which spread around in every direction.

When the diaphragm of a magneto-telephone is vibrated, the number of its vibrations per second governs the pitch of the sound produced; the amplitude of the vibration determines the loudness of the sounds produced, and the direction of the electrical currents is determined by the direction in which the diaphragm happens to be moving, and exercises an effect on the permanent magnet at the distant end of the line.

In this instrument the speaker talks to an elastic disk of thin sheet-iron, which vibrates and transmits its slightest movement, or a duplicate thereof, electrically, to a similar disk in a similar telephone at the distant end of the line, causing it also to vibrate, co-incidently and harmoniously, and therefore to emit sounds closely identical with those uttered at the transmitting end.

The telephone, then, at the transmitting end of the line acts the part of an instrument to transform sound into electricity, which it does in the following manner: The sounds uttered by the human voice strike against the diaphragm and cause it to vibrate; its vibrations in front of the permanent magnet causes magneto-electric currents to be induced in the coil which surrounds the pole of the magnet, and these currents, of course, traverse the line to which the coil is connected, and act upon the receiving telephone at the distant point.

The receiving telephone, in its turn, acts the part of

an instrument to re-transform the electricity into sound once more, and thus reproduce the tones against the diaphragm of the receiving station; for as the currents set up by the sending telephone, after passing along the line wire, enter the coil of the receiver, the magnetism of the magnet core is, by the action of those currents in the coil surrounding it, so modified as to cause it to set up vibrations in the diaphragm which exactly correspond in form to the vibrations of the transmitting diaphragm, and thus the original sounds are reproduced, with the exception that, the amplitude of vibration being considerably less, the sound is much fainter.

The telephone is a bar magnet of hard steel, inclosed in a case of hard rubber. It is provided with a vibrating diaphragm, which is clamped between the telephone case and the cap forming the mouth-piece; the latter also being made of hard rubber. On the diaphragm end of the magnet is placed a coil of wire which, by means of two screw posts on the end of the telephone, is connected in the line circuit.

In any line circuit, one magneto-telephone at each station is all that is absolutely necessary; and no battery is then needed, because the one which is being used as a speaker generates its currents to order.

As we have already seen, inside the telephone case is a permanent magnet, and from the pole of this magnet lines of force radiate through the coil and also in the direction of the diaphragm. When the diaphragm is vibrated, these lines of force are changed, and when

those passing through the coil are changed, currents are generated in the coil and traversing the line wire to the distant station they there flow around the telephone coil, either in one direction or the other, and thereby increase and decrease the strength of the magnet, and as a natural consequence the said magnet attracts its diaphragm with correspondingly varying degrees of strength.

Thus every movement made by the transmitting diaphragm under the influence of speech is necessarily repeated by the distant receiving diaphragm, which therefore causes similar vibrations in the air, and thus reproduces the sound.

The magneto-telephone, as at present constructed, is a small and conveniently-shaped instrument, and is almost universally used as receiver alone, as it has been found that when used as a sending instrument its tones were too feeble for an extended practical use. Hence it has been largely superseded in this direction by one form or another of the well known battery telephones which will be hereinafter discussed.

The foregoing description of the characteristics, general features and operation of this wonderful instrument may convey a fair idea to the mind of the principles embodied therein.

Such, in general terms, are the essential features of the telephone. In order, however, to afford a more complete understanding of its working, and that its peculiarities may be thoroughly comprehended, we will enter more into detail; for the telephone resembles the

fairer part of the human race in this, that it must be understood to be appreciated.

The magnet is made of four distinct pieces of steel, each one separately magnetized, laid together in pairs, with similar poles together, thus forming a compound magnet and one less likely to lose its magnetism. At each end between the two pairs is placed a soft iron core, or pole piece; the shorter one is placed at the end intended for the handle, the longer at the diaphragm end. The coil, which is of very fine silk-covered copper wire, is placed on the longer core, and ordinarily measures about seventy-five ohms. Its wires are continued down beside the magnet, and soldered to two binding screws at the end. The diaphragm is simply a thin round iron plate, such as is used by photographers to prepare ferrotypes on. The hard rubber case is made by the India Rubber Comb Company of New York.

In order that no foreign substance, such as a shaving of rubber or a particle of metal shall be loose within the case, and sooner or later cause trouble by working into and effecting a lodgment in some place where it should not be, the case is varnished inside by shellac varnish, which is also freely applied to the magnet itself.

Until lately it has been the practice to fill up the case with beeswax, paraffine and rosin for the above purpose, but this practice has now been discontinued, as it was found that small pieces of the compound would chip off and stick between the diaphragm and the magnet core, thus impeding the vibrations of the former.

When the case is varnished inside, the compound magnet and coil is placed therein, and fastened by a screw at the lower end.

Reaching a shade above the level of the coil core, the case bells out and forms a seat for the diaphragm, which must be as close as possible to the core, without actually touching it. It is clamped in place by the cap forming the mouth-piece, which is screwed on. The instrument is now complete.

The telephone has a few peculiarities which are, perhaps, not so well understood as they might be. Some of these will now receive attention.

To speak properly through a magneto-telephone, the upper lip should just touch the mouth-piece, and the tone of voice must be moderate. The resulting sounds will be much clearer in articulation and much louder than if the speaker were to get inside of the mouth-piece (which, speaking hyperbolically, many persons do) and then shout loud enough to awaken his slumbering ancestors.

A case in point, which occurred at an exchange office where there had been no demand for transmitting telephones, the magneto-telephones having given complete satisfaction, is treasured up in my memory. Arriving at the place in question, as I approached the central office I heard frantic yells of "hello!" uttered apparently with the full lung power of some blatant demoniac. This continued until I entered the office, when the cause of the uproar was discerned in the person of a boy of thirteen, who coolly informed me that he always

hallooed like that; and then if the subscribers did n't hear him through the telephone, they would through the air.

A mistake frequently made is to keep the telephone mouth-piece cap much too tightly screwed on. The general impression appears to be that the tighter the cap is screwed on, the better it will work and the louder will be the sounds reproduced. This is not confined to employés of the telephone companies. Almost every gentleman, lady, ploughboy or tramp who handles a telephone may be seen to unscrew carelessly the telephone cap and then screw it up again, apparently using all his or her strength in the latter operation. The fact is that when the cap is screwed on with more than a moderate degree of tightness, the movement of the diaphragm is fettered and the loudness and distinctness of the reproduced conversation correspondingly decreased. It is well, therefore, after screwing on the cap, if it be ever taken off, which is, however, generally unnecessary, to give it a slight turn back. The difference in the result is sometimes surprising.

Occasionally a telephone will decrease in power after being used for some time. This may be due to one of the following causes:

First, it is possible, from some reason or other, such as a poor quality of steel which may accidentally have crept in, or from lightning storms, or from powerful electrical currents received by crosses from a foreign wire, that the magnetic strength of the telephone magnet may be greatly diminished, or even lost altogether.

To ascertain if such be the trouble, unscrew the cap, gently slide the diaphragm off, and try if the magnet be strong enough to support the diaphragm edgewise. That is, hold the telephone with one hand, coil downward, and present the edge of the diaphragm to the magnet core. If it will hold it, it should speak properly, and that is not the trouble. If it won't hold at all, don't try to tinker with it, but send it back to the supply department and have it replaced by a new one.

Secondly, speaking of the older telephones, or those which were filled up with the beeswax compound, if the telephone has been in a warm place, or if the weather has been unusually hot, the compound used to fill up between the case and the magnet may get soft and occasionally become so fluid as to run down and get between the core of the magnet and the diaphragm. When it again solidifies, the effect will be that the diaphragm will stick to the core and be thus impeded in its vibrations, or prevented altogether from vibrating.

The remedy in this case is obvious. Scrape the composition carefully from the core and from the diaphragm; rub both with a rag moistened with spirits of turpentine, and again screw on the cap, occasionally taking a look at it, to prevent a recurrence of the trouble.

Should it ever happen that telephones are used on a battery circuit, see that the zinc pole of the battery goes to that screw-post of the telephone which is marked Z. In other words, if the copper pole of the

battery at the office is to line, the wire leading from the office must be connected to that screw-post which is *not* marked Z. If the zinc pole *is* to line, the wire from the office must be connected to the post which is marked Z. Then if the battery has any effect on the telephone, it will be to strengthen its magnetism, instead of to weaken it, as would be the case under the opposite conditions.

It is scarcely possible that with fair usage the circuit wires in the telephone should ever be broken, yet they occasionally are. If no sound at all issue from the telephone, and a broken circuit wire be suspected as the cause, disconnect the telephone and place it in a battery circuit which is open. If the wire be anywhere broken, no sound will be heard on closing the circuit. If, on the contrary, the wires are perfect, a click will be heard at the moment of closing the circuit.

The beauty of the magneto-telephone is its simplicity. Simple in construction and simple in operation, where is the marvel that it has become what it has—the household representative of electricity? It can be modified indefinitely, and has been so modified, there being over a hundred patents issued on such modifications. But so long as there is the magnet, the coil and the diaphragm, there is the telephone—the magneto-telephone—and nothing more is essential to articulate speech.

THE BLAKE TRANSMITTER.

Who, in these latter days of electric mental and physical light, has not seen and spoken to the Blake transmitter?

It was the legitimate offspring of the microphone. The years from 1875 to 1880, or, in point of fact, from 1875 to the present time, comprise a wonderful series of electrical and electro-mechanical successes.

It is not purposed here to discuss or re-open the question as to who was the first inventor of the microphone.

It is sufficient for the subject contained in this chapter to know that Professor Hughes was, at all events, the one who in May, 1878, gave his invention to the public, and thus awakened anew the interest in such matters which, after the introduction by Edison of the phonograph, had to a certain extent become torpid.

The adaptability of the instrument to become a sender or a loud speaker for the telephone, which at this time was quietly working its way into active service, struck the practical mind of Mr. Francis Blake, a gentleman of an inventive and experimental turn of thought. The same idea also appears to have occurred about the same time to many other minds; but to the application of Mr. Blake, assisted by several experts of the Bell Telephone Company, was the reward given.

As before mentioned, in May, 1878, the microphone was first made public, and as early as August, 1878, the Blake transmitter was produced. Its intrinsic merits

at once made it a great commercial success, and at the present time about 65,000 instruments are in active operation.

We will now enter upon a description of the method by which the Blake transmitter speaks. Many persons suppose that it is but a modification or variety of that class of battery telephones in which the oft-repeated principle is involved, namely, "the variation in resistance under pressure" possessed by many substances, and notably by carbon. It is not so, however. The only resemblance between the two types, both excellent in their place, is that both act by varying a resistance placed at some given point in a battery circuit.

Every Morse operator must have noticed repeatedly that when he has pressed his key very lightly, so as to make an uncertain contact, the relay and sounder have shown a disposition to chatter, while when pressed firmly the relay and sounder have worked firmly.

This is, of course, due to the fact that when the key is lightly pressed the resistance is great between the points, while when firmly pressed the resistance is much less. The transmitter contact is precisely like this. Its work depends on the electrical properties of a bad joint; that is, upon the fact that the electrical resistance which the current experiences in passing from one electrode to the other, varies when the pressure between them varies, and upon the further discovery that they can be so mounted that the motion given by sound waves will produce corresponding variations of pressure to a useful extent without breaking contact—any absolute

break of contact being fatal to the transmission of speech.

The essential operating part of the Blake transmitter lies in the contact of the two electrodes through which the current passes. The minute movements of one of these toward and away from the other, under the influence of sound waves, causes variations of pressure which affect the strength of the current. These variations occur about 400,000 a minute, and I repeat that it is requisite that under these variations the electrodes shall not, even for the most measureless instant of time, part company.

Everybody knows what the Blake transmitter looks like; an extremely plain-looking box of the brownest of black walnut, with a lid or door opening on hinges and provided with a lock, the key of which, only on very rare occasions, succeeds in unlocking the door of any other individual transmitter. On one side of it is an inscription so loaded down with a list of patents that it is no wonder that the average lineman sets up the instrument with an inclination to that side. It is not a handsome or attractive looking instrument. Its pretensions to architectural beauty are about as well founded as are those of the Five Points House of Industry. Moreover, the internal arrangements are scarcely more inviting than the outside. But the good things of this world are, after all, fairly divided. The bird that sings, rarely boasts of gorgeous plumage.

Screwed on to the cover is a ring of cast iron, which carries a cross bar or spring lever, to which

at its upper end is attached a square block of non-conducting material. In this are inserted two springs, one of which is very light, the other comparatively heavy. At its lower end the lever is controlled by a screw. The diaphragm is insulated by a ring of rubber fixed around its edge. It is held on one side by a brass clamp and on the other by a steel spring with a little rubber glove on its end where it presses on the diaphragm. The light spring previously referred to carries at its lower end, which reaches to the center of the diaphragm, a little piece of platinum, which touches the diaphragm on one side, and the middle of a button of hard gas carbon which depends from the heavier spring on the other side.

Four primitive looking binding screws may be seen inside at the top of the back of the box, and a small induction coil stands in one corner, as if it had been a bad boy. The primary or inside coil has a resistance of about forty-five hundredths of an ohm, and the secondary or outside one, which is made of fine wire, has about 250 ohms resistance. It will be noticed that here are two totally distinct circuits—first, the primary circuit from the carbon of the Leclanché battery to binding post No. 1, starting from the left side of the instrument; thence to the hinge and carbon button, through the carbon to the platinum, up the light spring to the cast-iron frame, from that to the lower hinge and to one wire of the primary coil, through that coil and out by binding screw No. 2 to the zinc of the battery. The other circuit is much simpler. The two wires of the

secondary coil are connected, respectively, to the binding posts 3 and 4, which are connected in the line circuit. For example, the incoming line may be connected to screw 3 and screw 4 through the telephone to earth. In practice it is usually connected to marked screw-posts of a magneto bell.

It is rather singular that the precise reason for the employment of an induction coil in this instrument does not seem to be generally known. It is not only because induced currents have a much greater tension and consequently a much greater power of overcoming resistance, but also, and chiefly, because it has been found that although the range of variation at the point of contact when the diaphragm is spoken against is great and almost infinite in a short circuit, where a slight change of resistance is an important factor, it amounts to but a very small thing in a long circuit, where the external resistance is large to begin with. The induction coil overcomes this difficulty.

The resistance at the point of contact controlled by the diaphragm is constantly changing under the influence of the voice, and with each change a current in one direction or the other is propagated in the secondary coil by current induction, which current goes over the line to affect the receiving telephone at the distant end. The transmitters are always tested before they leave the shop, and unless in good order are not sent away.

The light spring carrying the platinum point is often called the "normal pressure" spring, and the other the "carbon" spring.

To adjust a transmitter, slack down the screw at the bottom of the lever until the platinum point just touches the diaphragm, then turn upward one full turn. This will usually bring the tone to its best condition. If, when you speak rather loudly, at a distance of three inches from the mouth-piece, it "breaks," turn it up a little more; if it be faint or muffled, turn it a little back. If the carbon be pulled backward, the platinum should follow it nearly half an inch.

It is a very unfortunate thing that, as I shall hereafter have occasion to refer to, the average inspector has a rabid desire to blame every trouble upon the transmitter. The truth is that it is a most harmless instrument, and much more likely to work properly than improperly, if it have only the slightest chance.

Inspectors of telephones, however, are much like the scriptural virgins, only instead of being evenly divided, half of them wise and half foolish, five of them are, as a rule, wise and forty-five foolish. The forty-five, when they visit a telephone subscriber, make it an invariable practice to do so with no oil in their lamps, and as the transmitter is a convenient instrument, it is generally credited with the trouble; and, moreover, as it is quicker and easier to take it out and put a new one in than to discover and fix the trouble, that is the procedure usually adopted.

The following are troubles likely to arise in the Blake transmitter, with their remedies:

Trouble in the secondary coil. This shows by appearing as if the whole arrangement had given out; neither

speaking nor hearing can be accomplished. Examine the binding posts 3 and 4 from the left side, and the fine silk-covered wire leading to these posts from the coil. If you discover the fault, common-sense will tell you how to remedy it. If you don't find it, disconnect the outside wires from the binding screws and twist them together, then talk and listen with the receiving telephone alone. If you succeed in doing so, it proves the trouble to be in the secondary coil. A dead certainty may be given to this test by now connecting binding screw 3 to one pole of the battery and the other pole of the battery to one wire of the telephone cord; then attach a long wire to the other wire of the telephone cord, and touch screw post 4 with the free end of the long wire. If you hear a click you have made a mistake and the trouble is not in the transmitter but in the call box. If not, touch at different points along the silk-covered wires, first baring them a little.

If the trouble be thus discovered, you can probably splice it; if not, the trouble is in the coil and the coil must be changed.

Trouble in primary circuits shows by the listening coming all right while the transmitter will not say anything. It may be caused by several different things —screw post loose, either No. 1 or No. 2; wire in primary coil broken; loose connection on the primary circuit, where it goes through the call-box; perhaps the platinum point does not touch the carbon; the small spring may touch the large one above the contact point, or the battery may be weak or otherwise out of order.

Sometimes it will be found also that the binding screws have become corroded and that a surface of salt or oxide has formed thereon. This would arise from the careless use of acid in the process of manufacture, and the only remedy is to scrape it off. These faults may be mostly found by inspection.

Remedies: For the first fault, screw them up. Second, test for a break with the battery and long wire if everything else fail. If the break prove to be inside the coil, the said coil, as before, must be changed. Third, examine all the connections in the call box. Fourth, screw up the adjustment until the platinum does touch the carbon, then adjust according to rule previously given. Fifth, gently bend the springs until they come to their proper position.

If the battery be weak, it may be detected by placing the telephone to the ear, after carefully examining every connection, and then gently drawing the carbon from the platinum. If the click at breaking and closing is not loud and strong, the battery is probably out of order and must be looked to. A good inspector will assure himself of that fact by an examination of the battery first thing.

Sometimes the talking will become weak after a few days of warm weather. This would likely be caused by the rubber glove on the end of the damping spring becoming soft.

Remedy: Insert between the rubber and the diaphragm a thin piece of silk, cloth or paper.

The rubber ring encircling the diaphragm also be-

comes occasionally sticky from the same cause, and, impairing the vibrations of the diaphragm, also makes the talking weak. Remedy, insert paper.

Occasionally the transmitter makes a continual humming noise. This may be caused by the adjustment being too low, or by the battery being too strong. In the first case, screw it up a shade. In the second, press the diaphragm through the mouth-piece, to stop it temporarily, and either wait with patience till the battery gets a little older, or for the time insert two or three ohms in the primary circuit. If the cause cannot be found and removed, the trouble is very likely a button of bad carbon, and the instrument should be returned.

If the tone, from being good becomes weak, and at the same time harsh and raspy, it is caused by the platinum wearing the surface of the carbon rough at the point of contact.

Remedy: Carefully unscrew the carbon, and rub it on fine emery paper until the polish is once more even and good.

Finally, my brethren, as in all electrical apparatus, when a transmitter is working well leave it alone, and never forget that when repairs or new adjustment is requisite the instrument is not a four hundred horse power Corliss steam engine, but a telephone transmitter.

DISTURBANCES EXPERIENCED ON TELEPHONE LINES.

When some future historian of the world engages in the ever-increasing task of recording the vicissitudes, changes and progress of this self-sufficient planet, and, after reviewing the dark ages of antiquity, the classic age of Grecian domination, the iron age of the Roman republic, the Augustan age of the empire, and the semi-barbarism of the middle ages, arrives at the present era, he will have no difficulty in deciding that the proper designation wherewith to immortalize it will be "the electrical age." For in this era we employ that unseen yet active, all-powerful and universal force or agency in almost every service that can be imagined.

If the school girl's definition of electricity, namely, "a force known only by its manifestations," be correct, as, with some modifications, it undoubtedly is, it must still be conceded that its manifestations are illimitable, and that the human race has accomplished great results in subduing so thoroughly what was, even until the present century, so untamable, wild and free.

We send our thoughts over land and sea; we speak to distant friends and correspondents without leaving the fireside; we light our gas instantaneously, without regard to the number of burners; we leave our banks and counting-houses secure; watch our watchman; spread our fire alarms; explode our mines; regulate our clocks; light our streets and halls; keep one day ahead of the weather, and ring our domestic bells by the aid

of the wonderful and mysterious force; and yet we do not know what it is!

Those who know it best regard it as a form of energy which causes the infinitesimal particles of matter to alter their positions in regard to one another.

The telephone, though not discovered until 1876, is based upon one of the best-known properties of electro-magnetisms, namely, the fact that "when a spool of wire with a soft iron core is fixed on the pole of a permanent magnet, any alteration in the distance of an armature placed in front alters the magnetism of the core and sets up a current in the coil wound on the bobbin."

It is scarcely necessary at the present time to give a detailed description of the construction of the telephone, seeing that it has become, so to speak, a household word among the American people, and especially since a special chapter is devoted to the instrument itself.

Suffice it to say, in explanation of its action, that the diaphragm of the telephone, when put in motion by the voice, vibrates, approaching and receding from the core and, thereby, under the law quoted above, sets up currents in the wire of the spool, and consequently in the line wire to which it is connected; these currents pass along the line wire, and arriving at and passing through the coil of the distant telephone, act on its diaphragm, and set up vibrations exactly corresponding to those of the initial diaphragm, and thus reproduce the original sounds.

The currents caused by the very small movements of the diaphragm in front of the magnet are necessarily extremely feeble; so much so that the late Professor Pierce of Boston compared them to those which would be produced by an electric source of which the electromotive force should be one two-hundred-thousandth part of the power of a Daniell cell. It is, therefore, evident that the apparatus which can be distinctly acted upon by such currents must be correspondingly delicate and sensitive.

We see, then, that the very sensibility on which the legitimate action of the telephone is so dependent becomes, under certain circumstances, positively detrimental, because it is thereby rendered equally subject to be influenced by very slight external or foreign currents; in fact by any extraneous causes which affect the electrical condition of the wire.

As an inevitable result of this extreme sensibility to external currents, which are usually stronger than the delicate magneto-telephonic currents, the latter are to a certain extent overpowered by the former, whether acquired from the earth, or by leakage or induction from other electrical conductors; and the manifestations of the foreign currents in the receiving instrument of the telephone wire are similar to those exhibited on their legitimate apparatus, while the vocal transmission is correspondingly weakened. We will now consider and endeavor to classify the different disturbing sounds heard in the telephone, and then trace them to their several originating influences.

These may be arranged in five classes:

First: Frying, hissing and bubbling noises.

Second: Screaming and whistling noises.

Third: Jerking and rasping noises.

Fourth: Morse or other telegraphic communications in course of transmission on other wires.

Fifth: Telephonic conversation or vocal sounds in process of transmission on other wires.

Of course, the telephonic lines are also subject to interruption from other causes, such as breakage of wires, circuits accidentally left open, crosses, or contacts with other wires, and escapes or grounds; but these troubles, being comparatively well understood, do not come within the scope of the present chapter.

The noises and disturbances of the first and second classes are, I conceive, almost totally due to earth currents, atmospheric electricity and thermo and hydro-electric reactions.

Earth currents are now known to be always traversing the wires. They affect lines running north-east and south-west most frequently, and vary with the time of day.

There is, likewise, always free electricity in the air and in the clouds, which acts on the earth and on the wires, the latter being generally conductors to earth.

These noises are much more intense by night than by day, on long lines reaching their maximum about 12 midnight, the disturbances of the second class, screaming and whistling noises, becoming especially intolerable in the night.

M. Gressier, a French philosopher, accounts for these disturbances as follows:

"During the day the current developed between the wires and earth-plates on the one hand, and the earth itself on the other, the poles being the conducting medium between the two, are directed from the line to the earth, because the heat of the wire is greater than that of the earth, the currents being then thermo-electric." During the night the wire becomes cooled, while the earth retains its heat; the currents then flow from earth-plate to line, and are hydro-electric. No line in which the earth forms a part of the circuit can be totally free from these disturbing influences; consequently, the only radical remedy for them is the use of a metallic circuit. This being very expensive and inconvenient, it is well that disturbances due to the foregoing causes are not so violent as to interpose serious difficulties in the working of the lines, with the exception of very long ones when the battery transmitter is employed.

More recently, another eminent Frenchman, M. Gaiffe, has devoted much time to studying the various causes for these noises, and among other deductions made by him is the following: "Every change in the position of any wire, relatively to that of other wires on the same supports, causes magneto-electric currents in the others." This is especially the case with wires carrying heavy currents, and as this deduction is really based upon the solid truth of the phenomena of magneto electricity, it may be well believed.

We now proceed to the third class of interfering sounds—jerking and rasping noises. These I regard as being chiefly attributable to defective joints in the line wires and loose connections in instruments. Such imperfect contacts set up true microphonic action, with its resultant sounds. The remedy for this class is obvious: More care in making and soldering joints, and more attention to the inspection of instruments and lines.

We now come to the disturbances which constitute the worst enemy of the telephone electrician, namely, those which I have arranged in classes 4 and 5.

These are undoubtedly due to a variety of causes, the principal of which are leakage of currents from other wires; electro-dynamic induction and static and magnetic induction; those of the fifth class being also referable to the surcharging of insufficient and inefficient ground wires in central offices.

The first cause, leakage, is not exclusively an attendant on telephone lines, being likewise an old bugbear of all telegraph lines. Imperfect insulation allows the current to divide itself between all the wires on the pole, in proportion to their respective resistances; and as the shorter the wire the less the resistance, the tendency is to escape from a long circuit into a short one. When the current escapes to the earth, no great harm is done, as the only effect is to weaken the signals; but when it leaks into another wire, it confuses the signals on the second line. This evil used to be called in the United States "weather cross." Theoretically, the

best remedy for it is perfect insulation, but in this sublunary sphere perfect insulation is as hard to obtain as unalloyed happiness; therefore, as we cannot prevent the evil, we must attempt to obviate or neutralize it. I would advocate the best insulation procurable, but when all is done that can be done the fact remains that leakage does in some degree continue to occur, and where there is any the telephone is promptly on hand to report the fact. It is obvious, therefore, since we must expect currents to leak from the wires, that in preference to allowing them to pass from one wire to another they should be induced to pass to earth.

This idea was first promulgated by Edward Highton, one of the early English telegraph engineers. He patented the arrangement as early as January 29, 1852, and his method of application was substantially the same as that adopted many years later by Varley, which was also patented in England and America. The subject of Highton's patent was "Placing an earth connection around the arms or supports, about midway between each wire, so that any electricity that escapes from one wire cannot possibly reach or affect another one."

The application of this system in actual practice may be described as follows:

A thick wire is attached to each pole, coiling the earth end in a spiral under the foot of the pole and letting the upper end of the wire project above the top of the pole, to serve as a lightning conductor. Wires are then attached to the under side of the cross-arms, and

one end fastened firmly to the insulator pins, while the other end is firmly spliced and soldered to the thick wire running down the pole. The leaking currents thus find it easier to go to earth than to any other wire. As no insulation is absolutely perfect, this arrangement should be applied to all long lines. It is, of course, most effective when the earth wire is attached to every pole. The earth wires, however, do more harm than good when they do not make a good earth connection; and it may here be stated that a buried plate to which the pole wire is soldered is the best earth. In some places the earth wires have been merely coiled a few times round the butt of the pole. Such a contrived earth has, on its resistance being measured, been found to vary from 2,100 to 6,000 ohms. It cannot, therefore, be commended. If good earth cannot be obtained in some places, an uninsulated wire may be run from pole to pole, connected to the earth wires on the cross-arms, and put to earth at convenient points.

This subject is fully discussed in Culley's "Handbook," and Preece's "Telegraphy." The arrangement, though well known in England for many years, was patented by Mr. Varley in this country in 1868, and in a recent patent has been improved by the application of metallic sleeves, or sockets, in the cross-arms, to which the lateral earth-wires are attached, and in which the insulator pins are inserted; also by running the uninsulated wire attached to all the ground wires throughout the whole length of the line.

Besides grounding at each pole, the best results are

attained by connecting ground wires with this uninsulated wire at every convenient place for so doing.

When well applied, the earth wires carry off a large percentage of the interfering currents.

Electro-dynamic induction is the next cause, and, after leakage, is the most troublesome. It is very difficult to render in a clear manner, to persons unacquainted with electrical phenomena, the idea expressed by the word induction. The majority of those actively engaged in the telephone business, it is well known, are not practical electricians, and for this reason the word induction, spoken and written of a few times in reference to telephonic disturbances, has been eagerly snapped up and applied indiscriminately to all kinds of such disturbances. It is, however, a well-defined term; it has a well-defined meaning, and laws thoroughly understood. It was studied by Faraday, who made public his experiments with their results. Induction, briefly expressed, is the name given to electrical or magnetic effects produced in bodies to which the exciting cause is not directly applied.

Dynamic induction is the power which a current in motion has, when flowing in a conductor, of inducing currents in neighboring conductors. The most obvious remedy for troubles originating from this cause is the employment of a return wire, parallel and near to the first, instead of an earth return. Under such conditions, the currents induced on one wire would be neutralized by those resulting from the same induction on the second wire, which would then act in an opposite

direction. This, however, would only be efficient when the wires were near each other, and both equally near to the disturbing wire. This idea was early proposed by several persons.

Another idea was broached by Mr. Preece, in a lecture before the Royal Society in 1877, which I am disposed to regard as effective. It applies both to static and dynamic induction. Static induction, it may here be well to explain, is that influence which an electrified body has on all conducting bodies in its immediate vicinity.

Mr. Preece's proposed remedy was to interpose between the telephone wire and the other wires a conducting body in communication with the earth, and capable of acting as a screen to the induction, by itself absorbing the electro-static effects. He suggests a practical application, in the employment of insulated wires covered with an iron or metallic case, the case being in direct communication with the earth. It is my impression that the outside conductor, even if unconnected with the earth, would very much counteract the dynamic induction, by setting up a counter induced current to that of the inducing wire, and also by absorbing into its greater substance the currents which would otherwise be divided among the other wires on the same poles.

The earth connection has practically the effect of an increased nearness of proximity to the earth; since running a wire from the ground to the line wires amounts to much the same thing as bringing the lines near the ground.

The interference between the different line wires is diminished, but a distinct fault is originated.

We allude to the retarding effect of the earth upon the conducting wires. For, where wires are used to convey electrical currents and are placed near the ground, the presence of the earth tends to hold the said electricity upon the conductor wherever it happens to be, and when a message is spoken into one end of the conductor, owing to this retardation, it drags, and articulation is thus impeded at the receiving end; and, if the line be indefinitely elongated, the sound must become subdued into nothing and the spoken words unintelligible.

I am not aware that this remedy of insulating the conductors and then surrounding them with a conducting medium in connection with the earth has ever been applied to pole lines.

Its chief objection would be the expense, since the retardation at least for as long a line as five miles would be inconsiderable.

It has, however, been applied to conductors when grouped together into a cable, and gives satisfactory results.

First recommended, so far as the telephonic application is concerned, by Preece, it was, in 1877, tried on the Post-office telegraph lines in England. Subsequently it was applied to telephone lines by C. E. Chinnock, of New York, an American inventor. It was then discovered that a French physician had laid down the principle, applied it to telegraph cables in 1869, and patented

the cable. Many telephonic cables have now been constructed on this plan, and many modifications have been made which are more or less valuable, but they are nearly all based upon the same idea, namely, to coat each insulated conductor with a metallic or conducting surface and then to place all of the external conducting surfaces in connection with the ground at every available point.

Even in ordinary cables, however, the more wires there are in such a cable, the less must be the disturbances, since the interfering currents, like all other currents, must divide in direct proportion to the number of conductors, other things being equal.

Twisting the several conductors into a regular braid has a very good effect; as also a variety of conductor, lately patented by Dr. Orazio Lugo, in which a conductor is arranged in solenoid form, one wire of the circuit being straight and the other spirally wound around it, thus forming practically a huge helix. It is claimed for such a cable that inductional disturbances of all kinds are by its use obviated.

As regards the size of line wire, it is rather unfortunate that two obnoxious forces, leakage and induction, are at swords' points, leakage being lessened by the use of larger conductors, and induction correspondingly increased, and consequently diminished by the use of smaller ones. No remedy for this is at present discernible.

But such astonishingly good results are obtained by the use of small galvanized iron and steel wires that I am disposed to recommend their use (except in smoky

localities) for all lines which do not exceed ten miles in length.

Wherever such small wires are used the stillness of the lines is very noticeable and its comparative immunity from interfering noises remarkable.

Much of the interference between wires centering in the same office arises from the fact that far too many wires are worked from the same earth terminal, and *that* connection being often none too reliable. I am in favor of multiplying ground wires at central offices, of using larger ground wires, and of insisting on more care in their attachments. Too much stress cannot be laid on this point.

When two long lines are parallel to one another for some miles, and one is longer than the other, the tendency of the long line is to disturb, by extra currents, the shorter line. It considerably helps the matter to make the resistance of the lines equal by adding a resistance coil to the shorter line at the station where it terminates.

The problem of long line telephony is rapidly yielding to the energy and thought that have been applied to it, and will, no doubt, soon be solved. When it is done, we shall probably be surprised to see how easily it was accomplished.

With more powerful transmitting instruments, more effective receiving instruments, better insulated lines, and a good ground wire at each end of the line, and no other lines attached to it, we may daily expect better results and improved work, particularly when all known means for obviating line disturbances are employed.

THE TELEPHONE SWITCH-BOARD.

Nothing is more important to the telephone exchange manager than the switch-board. It is, as it were, the central sun around which all his other apparatus revolves—the medium through which his respective instrumentalities gain an operating hold upon the lines radiating from the central office, and thereby to the subscribers' offices located thereon.

Culley, one of the authorities in electrical literature, particularly that class relating to the transmission of intelligence from one point to another, defines a switch-board in the following terms:

SWITCHES OR COMMUTATORS.

"These are employed for connecting one circuit to another, for dividing a circuit, or for any purpose where connections have to be altered more frequently than it would be convenient to do at the test box."

Pope, an equally good and an American authority, uses almost the same words, viz.: "These are employed for the purpose of connecting one circuit with another, for dividing a circuit into two parts, or, in short, for any purpose where it is necessary to alter the connections of a line or circuit."

Prescott says the object of a switch is to "facilitate the making of the necessary changes in the connections of the wires," and "for interchanging the wires among themselves."

This last definition gives the key to the name, "com-

mutator," generally given in European countries to this piece of apparatus. The word "commutator" may be explained literally by the word "interchanger."

The switch-board, as generally used by telegraph offices in this country, has never found much favor in England, its place being filled to a measurable extent by the testing board, a plain board on which binding screws are symmetrically arranged, to which the several wires are led, and which are then connected as may be found desirable by short wires.

The above-mentioned fact may account for the absence of switch-board patents taken out by English inventors.

It is a fact that the published abstracts of English electrical patents from the earliest ages of antiquity to the year of 1868, A. D., disclose no patent for the switch-board; consequently, that class of inventors who make these abstracts the basis of their productions have had to go it alone, if I may so speak. Moreover, extremely little was done in this line of invention, or rather patented invention, even on this side of the Atlantic, until 1867, when Brownson, of Wellsville, Ohio, patented a switch-board whose front was so covered with little brass studs and buttons as to remind one of a French accordion, while its rear was such an inextricable network of wires as to compare favorably with the celebrated labyrinth of Crete. The writer, in the days of his ardent youth, ordered one of the first of these switches, and well remembers the unspeakable awe with which he was wont to contemplate its mystic

glories. This, however, though one of the first patented, was by no means the first invented. The first switch-board of which I have personal knowledge, was that devised by that veteran of the telegraph, J. Murray Fairchild, of New Haven. It consisted of a series of dials, arranged each with metallic studs around its periphery, connecting with the several lines, and provided with a button pivoted at the center of the dial and capable of being placed upon any one of the studs, thus changing the course of the line which was permanently attached to the button. Each line entering the station had one complete dial, and the button at the center was the terminal of the line.

One stud of each dial was connected either to the ground wire direct or to the ground *via* a main battery, and when the pivoted button rested on that stud the line was in its ordinary condition terminating at that station. The other studs ranged around the periphery of each dial might be numbered, and all the similarly numbered studs are connected together; for example, No. 1 stud on No. 1 dial was connected by a wire behind the board to No. 1 on every other dial, and No. 2 stud on No. 1 dial to No. 2 on all the other dials and so on. It is, of course, obvious, that if any two pivoted buttons were placed on similarly numbered studs the lines connected with those buttons would be united by means of the studs and their connecting wires.

This switch-board was invented by Mr. Fairchild away back in the fifties and until quite recently held a

place in the Western Union offices of New Haven, Bridgeport, Stamford and South Norwalk.

The largest and most perfect board of this construction ever erected was one set up in the American Telegraph office in Boston, in 1865, and fitted with spring-jack and wedge attachments by G. F. Milliken.

For its time, this switch-board was a really ingenious and useful piece of mechanism, as is unwillingly attested by several subsequent inventors, who, without knowing anything of the Fairchild board, have independently invented or devised the same thing. No switch-board has had the honor of such frequent invention as this. Mr. Fairchild did not patent it.

The Culgan switch was a Pittsburgh idea and came out in 1868. In it the line wires were led to upright metallic strips ranged on the face of the board, and attached to them by screw posts at the top. Cross wires were run on the reverse side of the board, in connection with binding screws on the edge, to which the instrument wires were led, and with pivoted buttons arranged between the strips and capable of being turned on to the strip on either side. This had a fairly long and useful life, and is even now used considerably in western Pennsylvania and New York. Those who desire to know more of this board, will find it fully described in "Pope's Modern Practice of the Electric Telegraph." And any person desiring to see one in all its glory, may do so by visiting the telegraph office of the L. S. and M. S. railroad at Brocton, N. Y. This switch, though fairly satisfactory, yet had

some disadvantages. The pivots would work loose and invisible troubles would arise, and the circuit manager would need a good "eye-glass in his ocular" to discover their source. Its general employment, too, was but evanescent. It was in due course succeeded by the Western Union pin switch, which is now known, I may almost say, the wide world over. It is, indeed, so widely and well known that a description seems superfluous.

None of these switches were ever patented, although more worthy of that honor than many of the nondescript appliances lately given to a confiding public, and protected, for no earthly reason, by the mystic formula, "My invention relates to electric switch-boards, etc." All the switches heretofore mentioned were designed for telegraph service, and the inventors of the same appeared to recognize the fact that they were all mere modifications of one wide principle—namely, that of two sets of conducting strips, arranged upon a frame at right angles with one another, and some means to connect any one of one series with any one of the other series.

This principle is known as that of the Swiss Commutator or Universal Switch. It is very old, and has been liberally used on the continent of Europe. Like *Topsy*, it "never was born;" it "growed."

One other of the old switch-boards deserves notice; namely, the Jones lock-switch. Its distinctive feature was that two sets of metallic plates were arranged transversely with regard to each other, holes bored at

each crossing point, and a slot cut in the hole of the upper plate. The connection was made by a plug or pin, provided at its lower end with a spiral spring, and higher up with a pin fitting loosely in the slot of the hole. To insert the plug, it was turned so that the pin slid in the hole, and as soon as it had passed the upper plate, it would be turned round. The pin, no longer coinciding with the slot, would, of course, hinder the plug from coming out. In later years this board was used as a telephone switch.

When the central office telephone business was introduced, it was largely manipulated by men who, though possessing marked ability, yet had no previous knowledge of telegraphy or experience in electrical communication; and, in fact, this lack of experience was emphasized by a supreme contempt for the professional ability of telegraphic electricians. The cry was: "Gentlemen, the telephone is a new thing, an instrument of surprises, and you must unlearn all you know before you can successfully handle it." In some things this was partly true, but our telephonic friends made the mistake of jumping at a conclusion from incomplete premises, and to-day, when the telephone exchange is one of the institutions of the land, none have achieved greater success, or have attained a more abiding prominence, than those who first graduated as telegraphic electricians. Holding the views enunciated above, it might have been expected that the labors of the contemned class would also be ignored, and such was the case. Instead of improving the switch-boards and

other electrical appliances ready to their hands, new ones must of necessity be invented, and the new inventions protected by patents. Hence the tremendous influx of switch-board and other patents. A careful examination of late switch-board patents will, however, show that very few really new ideas are exhibited by any of these so-called inventions, the majority of them being for some new and alleged improved form of connector between the vertical and horizontal-conducting strips. Occasionally—as in the device of Mr. Ellsworth, who shows a method of readily ascertaining which connecting strip is already in use—we find a new object gained, but not often.

To make a good telephone exchange switch-board, however, out of an ordinary telegraph switch, I admit that considerable remodeling is necessary; and after the first heat of invention was over, practical men began to look about them, to see the disadvantages they were laboring under and endeavor to overcome them. It was seen that time and money were, in telephone offices, the two main things to be economized—time, because speed of connection is the very life-blood of the business; money, because in many of the exchanges the telephone business was managed and owned by men of little or no capital; and, in others, the expense, in any case, would be great, and economy was necessary to make anything at all out of the business.

Soon, therefore, it became obvious that the telephone switch must be compact; all the apparatus must be

easily and quickly under control; everything about it must be well made and well put together; the motions required in a connection must be reduced to a minimum, and yet the apparatus must be cheap. The cry of cheapness for a long time obscured the vision of the practical man, and many switch-boards unworthy of the name were sent over the country; but a healthy reaction has taken place, and the general character of the telephone switch is much improved.

It was early discovered that an escape or a ground through a telephone did not apparently have the ruinous effect upon telephone lines that it has always had upon a Morse telegraph line, and this fact was utilized by the construction of appliances for listening at the central office, and thus supervising a connection which, instead of looping the listening telephone completely into the line circuit, merely connected it by a third leg to the ground; or, technically speaking, to the two lines connected for conversation. This practice was generally cheap, both in first cost and results, and does not rank as a success, especially where a long line is connected to a short one. It is found in practice that the listening telephone takes away much of the electricity. The best manufacturers now arrange to have the try telephone looped in.

The telephone switchboard, as at present made and sold, comprises the following distinct features: Annunciators to receive calls, connections with battery keys or magneto-electric generating engine, and suitable appliances whereby they may be temporarily connected

with any line to answer calls and to signal subscribers when wanted; appliances for connecting any two circuits for inter-communication; telephone connections for supervising connections and listening off, and frequently an annunciator between two circuits when connected to allow the subscriber, if he please, to ring off.

It is, however, noticeable in the highest degree that in those cases where the ringing off annunciator is provided the subscriber never cares to ring off, or forgets to do it if he does care; and, also, that wherever no such arrangement is provided it becomes one of the necessaries of existence to the said subscriber.

Every manufacturer, of course, thinks the switch manufactured by himself is the best, and no doubt all have their individual virtues. A very good one is made by Charles Williams, Jr., of Boston. It is generally made in desk form, with horizontal brass connecting strips ranged across both the upright and desk part, while two rows of annunciators are placed between the upright and inclined surfaces. The line strips are all at the back of the board, and are composed of a great number of springs arranged so as ordinarily to press their free ends together, and so form a continuous circuit. Not to trust too much to contacts, a wire connects each pair of springs permanently, and is also continuous throughout the length of the board, the whole series of springs and wires for each circuit crossing all the horizontal springs in front.

The horizontal metal strips are full of holes for the

insertion of metal pegs, and each peg so inserted forces itself between the two springs of a pair on any desired line circuit, thus making a connection between any line and any horizontal strip. The lowest regular horizontal strip is permanently connected with the ground, and to this all the lines are normally plugged. The next strip above is or may be permanently attached to the outer end of a power generator.

The peculiar feature of this board is, however, the device for connecting a listening telephone to any line or to any two lines. This consists of an extra horizontal strip, split longitudinally into two lengths. To these a telephone and transmitter are looped, and immediately below them, and forming part of the line circuit, is one of the pairs of springs heretofore described. When it is desired to insert the telephone into the line, all that is required is to thrust a double plug made of a piece of non-conducting material, faced on either side with a piece of sheet brass, into holes made in the split strip. This, of course, forces the springs below apart, and makes a circuit through the loop of the operator's telephone.

The line circuit when at rest and connected to ground as usual, entering, goes first through these listening springs, then to the annunciator magnet and back, traversing the line springs to ground; a branch also leading upward through other line springs, across the under surface of the upright connection strips.

Mr. Francis Blake, of Blake transmitter fame, has lately patented a unique switch-board. In it the cross

connection strips are represented by plates of metal of any desired shape and size. These are supplied in sufficient number, and each metal plate is separated from the next one by a plate of non-conducting material, such as hard rubber, of equal size to that of the metal plates. The lines are brought to small square plates placed regularly on the surface of the uppermost insulating plate. All the plates are piled one upon another—metal, rubber; metal, rubber; and so on. Taper holes are made from the small line plate through all below. Taper plugs are also provided, arranged in pairs so as to make contact only on the line plate surface and one of the plates below.

Thus, two plugs would be long enough to reach and make contact with the first metal plate below; two for the second, etc., *ad libitum.* Each pair of plugs is prevented from touching any intermediate plate by being made with a shank smaller than the hole. It is evident that, to connect one line with another, all that is required is to drop into each of the line plate holes one of the plugs of a pair, and this, making contact with the same plate below will make the required connection. This switch has been thought worthy of description on account of its novelty.

Heretofore it has been too much the practice of telephone companies to make frequent and radical changes in their switch-boards and systems. The practice is not commendable, and is being discontinued. If your board is not as good as new, and as convenient as your neighbor's, wait till you see one which you are

sure is the best. When you do change, first, get a switch-board by which the necessary changes and operations are *well* performed; secondly, one in which the same operations are quickly performed; thirdly, one arranged with rubbing contacts; and, fourthly, one in which the controlling telephones loop into the lines instead of grounding; and then you and all concerned will be better pleased, even if a good price have to be paid, than if the price were nominal, and you acquired a patent scarecrow.

A CHRONOLOGICAL SKETCH OF THE MAGNETO BELL, AND HOW TO BECOME ACQUAINTED WITH IT.

The present well-known magneto-telephone signaling bell is an aggregation of different inventions and mechanical movements, all of which have been added as it became evident that they were needed.

When the telephone became a business necessity, a compact, easily managed and easily operated call became also a business necessity.

Some devoted spirits who had got into a deep rut stuck bravely to their system of calling and signaling by breaking and closing the circuit of a galvanic battery. Longer heads, however, early foresaw that this would not do, and that a motive power which from its very nature demanded a complete rejuvenation every six or eight months was not the motor to make a practical success of the new instrument. It was also evident that a more popular method of signaling was imperatively called for. A vivid realization of what was required set the longer heads to thinking, and the result of the unusual effort was soon seen in the attempt to adapt magneto currents to the end in view.

The first attempts were crude, and, while the signaling currents were indeed generated by a magneto machine, it was one much resembling the early apparatus of Pixii and Clark. The generator was connected in one branch circuit at the end of the line, the telephones in another, and the signaling bell in a third, the several

branches being connected alternately by an ordinary three-point switch. The generating device was simply a pair of helices flying around in front of a large compound horseshoe permanent magnet, and the ringer was a modification of the ordinary Siemens' polarized relay.

Two troubles were speedily developed in this bell—first, it was difficult to arrange an armature sufficiently delicate to respond promptly to the rapid changes in polarity of the generator; secondly, it was not easy to cause the hammer to strike the bell hard enough to make a loud sound.

It is a well-known fact in natural philosophy that when there is a problem to be solved or a difficulty to overcome, provided there is, or seems to be, any money in it, the American inventor will be after it, and the chances are ten to one that he will succeed in its solution; for, like Cardinal Wolsey, "No man's pie is free from *his* ambitious finger." The present case was no exception to the rule.

Finding the ordinary polarized armature to be comparatively ineffective, the first, and still the most important, invention and improvement was made by Mr. Thos. A. Watson, who, instead of clinging to the steel armature, took a new departure by introducing in front of the electro-magnet of the ringer a soft iron armature, pivoted at its center, and being inductively magnetized by the proximity of one or more permanent magnets. This improvement made the magneto bell what it is, by at once increasing its range and making it extremely quick in action, and much less liable to

become incapacitated by lightning. The high resistance of the generating coil was now shunted ordinarily out of the circuit by a spring and button, and only cut in when a signal was to be sent.

The next improvement was the incorporation of the automatic switch. The object of this was to change the line from the bell to the telephone by the mere act of removing the telephone from its support. This was first done by H. L. Roosevelt, of New York. The advantage of such an arrangement was so obvious that many had doubtless done this before, and there are now many claimants for the honor of this invention; but, however the priority may stand, there is no question that Roosevelt was the first to protect his right by letters patent.

Just about this time the idea of the necessity of absolute privacy commenced to gain ground, and the secrecy switch of Doolittle and others was the result. This was next applied to the magneto bell, and for a long time was much used.

Soon afterward the battery transmitter was brought into general use, and it was at once seen that to use profitably the Leclanché, or any other open circuit battery, it was necessary to adopt means to close automatically the local circuit, when the transmitter was to be used, and to open it again on the completion of the conversation. This was done by several inventors about the same time, two of whom, Anderson and Briggs, of Cincinnati, patented the improvement, much to the disgust of others. The entire improvement

consisted in the attachment of another spring to the ordinary automatic switch.

Shortly after this the Siemens armature was substituted for the old revolving spools, by which substitution the power of the generator was greatly intensified and the ringing power of the magneto bell at this point was so strong that any bell failing to ring loud enough through a resistance of from 6,000 to 10,000 ohms was considered of poor quality.

Other improvements have from time to time been made in the mechanical construction of these bells, and each invention, while frequently futile itself, has pointed the way to something better. The power was first brought to the revolving coils by a gear-wheel driving a pinion fixed on the axis of the armature. This was superseded by a large wheel, the periphery of which was surrounded with a cord of rubber, which, by friction against a similar band of rubber on the periphery of the smaller wheel, revolved the armature. A very short lease of life was granted to this device, as it was soon found that the continued attrition between the two rubber surfaces ground its substance away. It was in turn superseded by the transformation of both wheels to pulleys, which were connected by a short but strong belt of rubber. The present method in use is once more a friction, but this time it is a rigid wheel of brass, working in a groove arranged on the edge of the smaller wheel, which may either be of metal or hard rubber. A high tension of electricity is obtained by the use of these magneto bells, and they will either ring

a bell or drop an annunciator through an extremely high resistance.

The latest improvement in this branch of manufacture is the automatic shunt breaking device. This is an ingenious mechanical movement so arranged that, while the high resistance of the generating coil is ordinarily cut out, as soon as the crank is turned the short circuit is broken and the generator is cut in.

What we want now as a further improvement is some automatic arrangement by which, when the telephone is being used, all the bell and generator coils in the line circuit shall be cut out; for it is an indisputable fact that every electro-magnetic coil in the circuit, especially when an iron core is inside of it, is a great hindrance to conversation, much more indeed than can be accounted for by the mere electrical resistance of the coils.

This magnetic retardation, as it is called, is due to the fact that currents opposing the telephonic current are constantly being generated at each coil, owing to the inducing influence of one convolution on another, and of the core on all. This trouble was recognized, and an attempt made to obviate it in some of the earlier Phelps call boxes, by bridging the coils with a condenser.

Mr. F. W. Jones, of New York, has also patented a system for shunting the coils of electro-magnets while the line is being used for conversation. I commend the subject to our manufacturing friends as one of some importance.

Not many instructions are needed for the proper management of these bells. In the first place an amateur telephone man should never undertake to connect a bell in circuit until he can understand its internal arrangements. The first time he gets hold of a new bell he should open it and commune with himself as follows: "This bell is to give a signal from somewhere else, so that for that purpose it must, when the telephone is on the hook, have a complete circuit through the bell magnet from screwpost to screwpost," and forthwith he will trace it out, and if he be wise he will make a diagram of it. "This bell is to be able to send signals to other places; it must necessarily, therefore, have a circuit from one line screwpost to the other, through the generating coil, when the short circuit around that coil is broken either by a finger button or by the automatic device before described, when the telephone is on the hook." This also he will trace and pencil down. He will say further: "When my telephone is removed from the hook, I must have a line through my telephone and transmitter, while the bell circuit is broken." He will examine and note that. Finally, he will see that his local battery circuit enters the bell for the sole purpose of being opened and closed when necessary, and he will trace the connections for that purpose.

Having thus, as it were, analyzed the bell, he will be better prepared to grapple with any trouble that may arise. When he screws his bell up he will, of course, see that each binding screw is tight, and that a

ground wire of thick wire is connected to the ground binding screw; and whenever he inspects the instruments at that office he will not fail to test both the generating and ringing power of the magneto bell.

TELEPHONE TRANSMITTER BATTERIES.

Telephone exchange managers, young and old, experienced and inexperienced, have had an interest in the question, "What battery is, under ordinary circumstances, best adapted for the operation of a battery telephone?"

The two battery telephones in common use, as is well known, are the Blake and Edison transmitters. The question is a serious one to all, and in various forms it has constantly been repeated ever since the inauguration of the exchange business.

This exchange business, this little giant of the Western hemisphere, has, no doubt, been the cause of a tremendous boom in the Leclanché battery. This battery was the first one to suggest itself as being most eminently suitable for transmitter work. Its comparatively high electro-motive force, or vim; its cleanliness; its freedom from corrosive acids and chemicals, and its longevity, all contributed to render its claim to notice a powerful one. It was at once installed as the transmitter battery par excellence; its virtues were legion, and its faults few and insignificant.

The months flew by and the managers and superintendents of small exchanges found themselves in charge of large ones, for the business, under the influence of popular necessity, had grown like the remarkable beanstalk of the fabled Jack, and the expense began to be a factor.

It was then discovered that the Leclanché had some

faults after all. It was expensive in first cost; it would soon become weak if used more than a few minutes at a time; it would, sometimes, without any apparent cause, get a very weak back and prove itself to be unable to do its work; it would corrode its own wires, and so on, *ad libitum*, to the end of the melancholy chapter. It was the old, old story; from one extreme the telephone expert had jumped to the other, and the battery that at first had no serious drawbacks, now was nothing but one gigantic fault.

Many persons undertook to experiment on transmitter batteries for themselves, with results more or less successful. One eminent electrician made a battery by filling a porous cup with a mixture of chloride of lime and crushed carbon round the carbon plate, sealing this mixture up and immersing the whole in a solution of common salt. He reported that the battery so made worked satisfactorily. It is not, however, recommended for general use, as it is apt to be disappointing.

Another man, ascertaining from electrical text-books that peroxide of lead was a better depolarizer for batteries than the peroxide of manganese, and finding out that De La Rive had experimented with it, forthwith jumped to the conclusion that he was the discoverer of this great fact in physics, and constructed, with immense enthusiasm, a battery using the said peroxide of lead combined with carbon, as the mixture to be placed round the rod of carbon in the porous cup. In course of time comes the chlorine battery inventor, describing his battery with a profundity of chemical symbolism,

and displaying a marvelous knowledge of chemical nomenclature. This invention was backed by Professor Carhart and ought to have succeeded, but it cannot be denied that it has so far fallen flat, after a short but vivid coruscation.

Soon came another battery aspiring to the favor of telephonists. Surely, in this the force of simplicity can no further go; for this cell has no porous cup and no depolarizer, but consists simply of two opposing plates immersed together in a solution of sal ammoniac.

This is now well known by the name of the "Law Battery," because introduced and manufactured by the Law Telegraph Company of New York. It possesses several well-defined advantages, chief among which, as previously indicated, is its simplicity of construction. Its extreme cheapness is also noteworthy, since it only costs $1.25 per cell complete, subject to discounts in quantities, and somewhere about ten cents per cell per annum for maintenance. The cover is tightly attached, so that evaporation or creeping of the saline solutions cannot ensue, and yet the cover can be easily put on and off at pleasure, as the sealing is effected by a rubber ring placed around the neck of the jar, over which the cover fits tightly. It is claimed by the introducers that the connections have never been known to corrode, and, as they are exposed to view, it is a very easy matter to determine the question. In the opinion of the author the chief fault of this battery is a lack of constancy.

It is very evident that this battery is precisely the same as the Leclanché, minus the depolarizer; and

necessarily shares in its faults while, owing to this very lack of a depolarizer, it is not, nor indeed can it be, so prompt in the revival of its strength when resting.

Some enterprising persons and electricians, acting upon the suggestion of J. T. Sprague, the English electrician, have endeavored to prove the Leclanché patent invalid, but there is no sufficient ground for such an assumption. The Leclanché battery, claiming the use of peroxide of manganese when moistened by a liquid containing a salt in solution which has no chemical action upon the manganese, the manganese to be in a porous cell, was patented April 23, 1867, and has, therefore, three years still to run. It was re-issued with much broader claims on February 17, 1874, and the patent for the Leclanché prism battery was granted July 13, 1875. This has still eleven years to run.

After the revolution, already recorded, against the Leclanché battery had taken place, the inevitable reaction set in, and it is once more regarded as a very fine battery—and by many, indeed, as the best, all things being equal—for a battery transmitter. On the score of economy, I am disposed to regard the prism form as the most desirable, as dispensing with a porous cup.

I will here give, for the benefit of the uninitiated, a short description of both.

The Leclanché cell, ordinary form, is simply a plate of carbon set in a cup of porous earthenware, and surrounded with a mixture of peroxide of manganese and granulated carbon. When full, this is sealed up by a resinous cement. The carbon plate sticks up through

the cement and is fitted with a cap of lead, surmounted by a binding screw, for connection to the circuit wire. Two holes are made through the cement.

The porous cup, with its contents, is then placed in a glass jar, which is filled to the shoulder with a saturated solution of sal ammoniac; while in one corner of the glass jar stands a rod or pencil of zinc, fitted with a spiral connecting wire, which forms the negative pole. This, then, is the ordinary form of the Leclanché battery. The object of the peroxide in the porous cup is to prevent polarization by absorbing the hydrogen produced by the galvanic action; the object of the pulverized carbon is to increase the surface of the carbon plate, and likewise to assist the manganese in its work, by presenting a number of salient points to work on. A cap of lead is placed on the carbon in order to form a good point of connection with the conducting wires, and the holes through the sealing mixture are provided for the escape of any gases that may generate in the porous cup.

To set up the battery, take about four ounces of sal ammoniac, put it in the glass jar, and fill the jar one-third full with water. Stir it up, pour about a tablespoonful of the water and sal ammoniac into the holes of the porous cup, then put the porous cup into the glass jar and fill it to the shoulder, never higher, as the drier the contents of the porous cup are, the better they will work. Put in the zinc, which should always be of rolled metal, and the cell is set up.

The prism cell is somewhat different in construction, although the principle is identical. In it, instead of

surrounding the carbon plate with a mixture of granulated carbon and peroxide of manganese in a porous cup, the depolarizer is formed of a mass composed of equal proportions of peroxide of manganese and granulated carbon, the whole held together by the introduction of from five to ten per cent. of some cementing substance, such as resin; the carbon plate is inclosed in this mass, and the entire substance is subjected to hydraulic pressure in a hot mold. The zinc in this battery may be of any desired form. The zinc forms one pole and the mixture the other. Both are fitted with screw connections, and immersed in a solution of sal ammoniac in the glass jar. This style is to be preferred, and is not so expensive as the other. In the use of the Leclanché battery in any form, care must be taken that the vapor of ammonia does not eat away the conducting wires. An occasional lookout should be kept for the formation of white lead between the carbon and its lead cap. If the battery fail to get up strength, ram a small screw-driver through the holes in the sealing mixture and see that they are clear. It frequently happens that they become stopped up and the gas cannot escape. If the battery be used in connection with a magneto bell, care must be taken that the wires are so connected that the circuit is completely opened when the telephone is hung up. It is also well to look out that the wires from the battery do not cross any damp place, otherwise a cross connection may occur, the effect on the transmitter being diminished, causing a bitter wail from the suffering patron of the tele-

phone. If the battery be in a warm place, the solution soon evaporates; therefore, don't put it in a warm place if you can help it; but if you can't help it, do your best to make it air-tight and inspect it frequently. In places where the transmitter is to be continuously employed use a blue vitriol battery.

A very good battery for those experimentally inclined is the alum battery. It may be made by procuring a supply of alum (it may be had in quantity for a very low price), and filling up a porous cell around a carbon plate with it, broken in pieces about the size of a small marble, and then immersing the porous cell in a solution of either sal ammoniac or table salt.

To sum up, the Leclanché prism battery still stands unrivaled as a telephone transmitter battery for general use, while it is also excellent for any other open circuit use, such as signaling subscribers and operating electric bells and burglar alarms.

It is by no means a bad idea for exchange managers to experiment on transmitter batteries, as they can then choose for themselves; and, perhaps, if they are willing to indulge in original investigation, hit upon something good and new, and so make a fortune.

For the transmitters of central office operators the gravity battery is decidedly the one to use, and it may be so arranged that when not in use it shall be shunted on to a high resistance, and so used economically.

LIGHTNING—ITS ACTION UPON TELEPHONE APPARATUS—HOW TO PREVENT OR REDUCE TROUBLES ARISING THEREFROM.

In these days of popular science, every one knows that lightning is the discharge of atmospheric electricity, and that it seeks, under all circumstances, the easiest and shortest route to the earth. The wide range of usefulness which the telephone has taken upon itself brings the subject of the present chapter home to every telephone manager and even to every telephone user. It cannot be denied that the majority of the latter class have a vivid impression that wires of any kind on a house make that house very liable to a lightning stroke, and that telegraph or telephone wires are especially subject to such a drawback. Many people who would otherwise rent and use a telephone are by this apprehension debarred from that privilege; or, if they have one, they live in a state of chronic disquietude, arising from the thought that they are harboring a destroying angel, as it were, who at any time may turn and rend them.

This apprehension is well known by practical electricians to be to a great extent without legitimate foundation; but, nevertheless, it prevails and cannot be overlooked. Only those miserable and unfortunate persons whose terrible doom it has been to solicit roof permits from householders can appreciate the sentiment in all its glaring force. The proposal to establish a fixture upon the roof belonging to a free-born American citizen

usually calls forth very severe objurgations upon the bloated corporations in the person of their unoffending agent then present. The assertion uniformly made by the agent that the wires running over a house are absolutely a protection, instead of dangerous, is treated by the American citizen with undisguised scorn, as advanced by an interested party. The American citizen cannot be so easily imposed upon. He has never seen any one killed by electricity, but he has heard that such things are possible; therefore he has no desire to have wires worked by electricity placed on the top of his house. He has been told that a wire leading from the top of a house attracts lightning. What can be more logical than that a wire running *over* your roof will also attract lightning, and, of course, after having attracted the lightning to the house, the death-dealing and treacherous wire has done its work because, as the wire does not run down the wall into the ground, the lightning must necessarily go through the house, in its endeavor to reach the earth. Such are the arguments of the free-born citizen, when he condescends to argue at all. The wires must, however, be stretched, and in fact always are stretched.

It is a fact also that where there are a sufficient number of wires crossing any roof, they form practically a much more reliable safeguard against destruction from lightning discharges than do fifty per cent. of the lightning rods, since they must, in order to perform their legitimate functions satisfactorily, form a good connection with the ground, in at least one of their terminals.

Even when but a few wires cross a roof they protect that roof to a considerable extent. That property is protected by the wires passing over it, needs no other proof than the fact that the lower part of New York, which is literally covered by a network of wires, has for many years possessed almost perfect immunity from lightning casualties.

This immunity to the property under and surrounding the wires is, unfortunately, in a great measure at the expense of the wires themselves, or of the fixtures, poles or electrical apparatus, as has been frequently proven by disastrous experience. During the past summer, the destruction has been unusually great among the coils of magneto bells, telephones and Blake transmitters. A certain amount of such trouble and annoyance must always be expected and counted upon, as one of the inherent features of the business.

It is the object of this chapter to enable amateur telephonists and others who have been brought by the force of circumstances into the telephone business to reduce this loss and annoyance to a minimum.

Telephone lines when properly constructed are not so liable to damage from lightning as telegraph lines, for the obvious reason that they do not usually extend over anything like so large a section of territory. Lightning will take the shortest path to the earth, even though that path be of much greater resistance than the longer route; hence, it has been found possible to construct lightning arresters or protectors.

Lightning is neither restricted to the properties of

machine or frictional electricity, nor to those of galvanic electricity, but partakes of the nature of both, being possessed of high potential in addition to being present in large quantity. This latter is, of course, due to the electro-motive force with which it is propelled being so enormously great in proportion to the resistance which the discharge has to pass through, even though that resistance be also immense. Being of such a high potential, or having such a high tension, as is demonstrated by its capability of passing through such wonderful distances of air as it does, it follows that we can construct a protector based upon the principle previously enunciated, that lightning will take a short route through the imperfect conductor in preference to a longer one through a good conductor.

Telephone managers, then, who have erected upon their lines the so-called induction appliances, consisting of ground wires extending down the poles and branch wires along the cross arms, can console their wounded pocket-books with the reflection that, even should these appliances prove ineffectual for the purpose for which they were erected, with a slight alteration (namely, continuing the connection of the cross-arm wire up to a point outside though not touching the insulator and facing the wire, and extending the upright pole wire a little distance above the top of the pole), a reliable lightning conductor is established and the poles and wire protected. Even in their present condition they do efficient service. Each magneto bell is or should be furnished with a lightning arrester of some kind, usu-

ally a plate connected with each entering wire placed close on either side of a plate with saw-like teeth which is connected to the ground.

Any one wishing additional security may add to this different forms of protector. For instance, it may be of use to place near the point where the wires enter the office a cylindrical piece of brass connected to the ground, and insert in the line circuit on both entering wires a piece of fine silk covered wire. The brass cylinder must be long enough to cross both line wires, and the piece of silk covered, on both lines, is coiled several times around the brass, so that the only thing intervening between the line and ground wires is the silk insulation, which must of course be unfrayed. The lightning, in this case, instead of passing through the magnet or transmitter coils will go to earth at the metallic cylinder. There is, however, a serious objection to all protectors of this class, especially when at a distance from the central office, for the reason that when a discharge takes place through them they are more than likely to be ruined.

On this account we give some precautions which every telephone constructor can employ with great advantage and at little or no additional cost. First, owing to the second attribute of electricity (its considerable quantity), it will heat, sometimes to the melting point, and destroy the wire, unless its conducting path be large enough and the ground wire be both low in resistance and of considerable size; and it will also, in its attempt to choose another route to the earth, be

likely to destroy a good deal of the apparatus, burning and melting the metal parts, and breaking to pieces all the non-conducting portions. It is the part of wisdom then with all those who deplore such wholesale destruction of property to see that they have a ground wire of large substance and also surface, and that such a ground wire makes a perfect connection with the ground. In a former chapter I gave my views on ground wires and will not repeat them here. It is not, however, as well understood as it should be that a lightning arrester ground, whether at a central office or at a subscriber's office, in order to be of any practical utility, must be of large size and, moreover, its connections must be of large surface and thoroughly attached. For size I should say not less than five-sixteenths of an inch, iron or copper wire. The connection may properly be made on a water or gas pipe as usual; but if a gas pipe be used and the connection made on the house side of the meter, the meter should invariably be bridged with a stout piece of copper wire, to improve the conductivity and also to prevent the meter from receiving damage.

Nearly all large exchanges have their central office cupolas fitted with lightning arresters of more or less value, usually less, just because they do not furnish sufficient ground wire capacity to carry off a violent discharge. The larger the ground wire the better, and the better it is connected with and the more surface it exposes to the damp earth, the safer it is for the building and apparatus.

There are exchanges which use no lightning arresters in their cupolas at all and yet have suffered no damage, but the only comment I care to make on the fact, is that they have been unexceptionably fortunate; and were I constructing an exchange, I should not care to follow such an example.

The older magneto-bells had but one binding screw for their local battery connection, and it was customary for the individual connecting them to connect the other battery wire into one of the main line connection screws. This, of course, left one end of the primary coil of the transmitter always in connection with the line, and in the event of the line receiving a lightning discharge a portion of it would frequently seek earth through the primary coil and across to the secondary, burning both out in transit. Therefore, if you have to connect a bell with but one local battery screw, don't connect the other battery wire in the line post, but in the upper telephone connecting screw on the right hand side of the bell. Bells are now made with binding screws for all the necessary wires.

Some exchanges have been fitted with protective appliances to be attached to their line wires on the approach of a lightning storm. These appliances are especially valuable in small exchanges, where all the wires can be easily controlled by one person. The contrivance consists, generally, in so arranging the apparatus that on the appearance of a thunder-storm all the lines are put directly to earth. A brass plate is arranged behind the switch-board, crossing all the wires;

this plate is fixed upon pivots, and is in permanent connection with a very large ground wire. On the approach of a storm a lever attached to the plate is depressed, bringing the plate into good contact with all the line wires, or with a series of small plates connected to them, at a point before the line wires reach the annunciators. This, of course, puts them all to ground and it is found that wherever this arrangement is used the destruction of bells and transmitter coils is materially lessened.

It can be readily arranged so that every line shall, at the point crossed by the brass plate, be fitted with a pair of spring contact plates, in order that, when pressed by the brass plate, all the lines may be severed from their regular ground through the annunciators, and be put to earth direct *via* the brass plate.

THE TELEPHONE INSPECTOR.

Not often do we see in print the legend, "Telephone Inspectors Wanted," yet in the issue of THE OPERATOR of October 15, 1881, such an advertisement appeared. It is not necessary here to go over old ground and name the advertiser. Those who are anxious to become acquainted with the name are respectfully referred to the paper of that date. The advertisement, however, proved that good inspectors are not to be picked up everywhere and paid the prices of day laborers. A good inspector in your exchange, and working for you, is worth ten thousand anywhere else.

There are inspectors and inspectors; there are men who to a telephone or local telegraph company are worth any price—their weight in gold, to speak hyperbolically—while there are others who are not worth their weight in "etheric force" or old individual bells. A really good, able and industrious inspector can, even under very adverse circumstances, often get good work out of a bad system and worse instruments, and can keep subscribers at least passive. But, on the contrary, a lazy, inefficient, or worse than all, a *careless* inspector can blight the fairest and most promising route of subscribers; can ruin the best instruments, without giving a week's notice, and can make the lives of the office manager and of all of his subscribers so ineffably miserable that, emulating the Brooklyn divine, they see no deliverance in this present world, and "even wish that they were dead."

If any remarks in this chapter should grate upon the feelings of such a one, let him congratulate himself, for in that case he is not incorrigible—there is hope for him if he reform at once. If similar remarks should, as "a bow drawn at a venture," hit any inspector who occasionally makes a mistake, but who, in the integrity of his heart, tries to do as well as he knows how, and always is anxious to learn more, let him not feel hurt thereby; from such a one criticisms glance off pretty much as water does from the plumage of the swan.

Before the mind's eye of the writer passes a typical inspector of the "not thorough" class. Although meaning well all the time, he rarely does well. He is called upon to attend to a complaint. The document is, of course, as lucid as the densest mud, probably couched in the impassioned words, "The thing won't work." Our hero goes off whistling, with a heart as light as hydrogen, and presently arrives at his destination. He at once wins the heart of the subscriber with his cheery smile, especially if he has n't been there before. After a pleasant word for every clerk in the store, and a genial smile for the lady cashier, he takes the offending instrument in hand. He finds the bell box to be one with the attachment recently invented by Edison, Johnson, Anders, Gray and a horde of other professional inventors, whereby the old button for cutting in the generator to the line is rendered unnecessary. In other words, a bell box with "automatic shunt breaker." On testing it he finds that he can't raise the central office. Fully competent, he makes up his

mind that as all seems to work properly the difficulty is, of course, that the shunt does not break. To get at the trouble he has to open the box, and discovers that he has left his bunch of keys in the key-hole of his drawer at the office. Misfortune the first. It will be remembered that this man is smart and able; his only trouble is thoughtlessness and lack of thoroughness. Therefore *because* he is smart, an idea flashes across his mind. He takes out his screw-driver, rapidly unscrews the line and ground wires and the transmitter battery, and tries, by connecting one pole of the battery to the ground and tapping on the other with the line wire, to drop the annunciator at the central office and attract the attention of the manager. Fortune favors the brave; the line is well insulated, the annunciator magnet well wound with fine wire, and the battery at its best, so he succeeds. He gets the manager to send the keys down by a boy, and after the boy has come and gone and he has opened the box and detected the trouble, he wants his pliers. He hunts for them in every pocket, and at last remembers that he did n't have any occasion to use them for two days; thought he would n't to-day, and so, as they were a weight to carry about, he put them in his tool drawer early in the morning. Ashamed to call again to the office, he, for want of the required tool, repairs the bell imperfectly, resolving to visit it again soon and then fix it properly, He then connects up the wires again, tests with the office, finds it works well, and goes off, forgetting to recover the battery box, but not forgetting to fresco the

carpet with ammoniacal salts and oxychlorides of zinc, which, while waiting for the boy, he had carefully peeled from the jar. He, of course, also forgets to go near that subscriber's office again to repair the trouble permanently, and in three days the same old difficulty is reported again. The subscriber, however, is n't so glad to see him this time, and if another man be sent *he* has to suffer for the fault of No. 1. But he goes on his way rejoicing, and is now on his regular beat. At one place he examines and tests bell, transmitter and telephone, but does n't look at the battery. If he had, he would have found the solution low and the zinc eaten off and scarcely touching, and saved a complaint. If he had done this, and had a zinc in his pocket—but this is opening too wide a field for conjecture, and I forbear. At the next place he fails to try the binding screws, and in a day or two a loose connection is reported on that line. At number four he remembers that Mr. Surly is not always pleasant, and he concludes that one miss won't matter. Ten to one it is all right, any way. At number five he makes a thorough inspection and finds all apparently in good order, but he does n't try the instrument to see if the talking is all right. If he did, he would soon find that Mr. B. had n't paid his gas bill, and that his meter had that day been taken away, and so on *ad libitum* to the bitter end. This man never carries a full kit of tools. He trusts to luck that he won't want them. He never carries sal ammoniac or extra zincs. He always leaves something undone, and he wonders why Jack Earnest and Sam

Careful always get ahead of him, when he is so many degrees smarter than they. Don't we know such men? It is well to emulate his smartness and shrewdness; but if you can only possess one good quality, let it be *thoroughness.*

We have all seen the lazy inspector. It is not necessary to name him. He won't go out after four. He always takes a car, even if his destination is but half a block away. He makes it a rule never to do too much. "The company is rich, you know." His motto is, "Never do to-day what you can put off till to-morrow," and he acts well up to it. He has a system. If he has a regular inspection route, he will have a little lottery with himself every day and draw cuts to see which house he shall *not visit.* He knows where all the free lunch counters are, and does n't forget it. The telephones are always in good order at the saloons on his route, and he can always be found, because every boy in the office knows where he will be at every hour in the day.

There are, however, certain times when he has a rush of business to the head. These occasions are chiefly when an inspector is required to locate a line trouble and there is only one besides himself in the office. He need scarcely trouble to be busy at these times, however, since the manager probably knows that if *he* goes out on a line trouble, a snail's gallop would be two-forty time compared with his, and the other man will invariably be chosen.

I know another inspector who is as smart as our

first specimen; who can do anything in the world with wires; who invented a button repeater before he cut his eye teeth; who can make a diagram quicker than Gerritt Smith can think of one; who is unexcelled on locating breaks, grounds and escapes; who knows every time, from the way a fault acts, what causes it; who is quick, sharp, careful, and who would be invaluable, provided he would consent to apply his talent for the company which pays him, and to his regular duties. Unfortunately, however, that is the one thing he won't do. If he should, he would be perfection. If he is wanted to go out and attend to a reported trouble, he will be found in the back room making an induction coil. If he starts out to locate a ground, he will have to stop when he passes the switch-board to explain to an aspiring young electrician why an annunciator placed in the common ground wire won't work. If he is wanted to relieve the manager for an hour, he can't be found, and upon anxious inquiry it is elicited that he has just stepped up to Tom Edison's new place, you know, to tell him that he has no chance against Maxim, except by stock-jobbing electricity. He can make wonderful shocking machines. He can make an electrical clock out of a battery pole-changer. All the boys in the office regard him as the greatest man that ever lived, and the girls unanimously pronounce him "too smart for anything;" and so he is. He is valuable because he knows almost everything. He has a private contract with all of his subscribers, that he will have a regular day to come around; and if the instrument

don't work, not to complain to the office, but to wait and tell him. Of course there can be nothing tangible against him, as he always covers well his tracks when he meanders from the paths of professional rectitude. He is handy, but there is a general impression that he is not reliable; and a standing joke goes round occasionally, when the manager wants the room where old apparatus and instruments are kept cleaned up, that all there is to do is to send Ed. Coilmaker into the room for a day or two, and it won't need any more cleaning.

I know another man who ought to quit the business. Although well-meaning and pleasant, he is simply the wrong man in the wrong place. He used to be a telegraph operator. He can handle a key with celerity, and, if necessary, can to-day copy twenty words behind; but he is not an inspector. Inspectors are born, not made. If you send him out to detect and report upon the nature of a trouble, he will report an escape when the trouble is a broken wire, and *vice versa.* He will have his superintendent put a steady battery on to aid him in locating an escape. He will rip out a transmitter because the battery is dry, and report a weak magneto generator when the trouble is a bind in the drop at the central office. If he goes on the roof or into the cupola to change a pair of wires, he will probably connect one to the lightning arrester ground and the other to your most important extra territorial line. He always connects the battery wires to the secondary coil of the transmitter, and includes the telephone in the primary. If he gets anything accidentally right,

he is astonished, and so is everybody else. He has one excellent feature, however, namely, his unfailing good nature. He is not to blame, only he had better go back to the key, study law, or apprentice himself, while the lamp holds out to burn, to a tailor.

But while patiently considering these various typical inspectors, there is one who at length steps forward, modest and unassuming. He is one that the experienced manager delights to honor, and that honor takes the shape usually of extra and difficult work. If an inspector acknowledges himself beaten, John Springjack has to show him. If successive inspectors and linemen fail to find a swinging break or escape, John is called upon to do it, and does it. When he goes on a complaint, he first looks over his tools. If he has to work on carpets, he carefully spreads a newspaper on the floor. If he has to fix a battery, he will carry it into the kitchen. He will not leave a job till he knows it is done, and done well; and when John pronounces it done, everybody knows it is done. He always examines and tests every part of the apparatus, and tests it thoroughly.

He is wise in his day and generation, and when anything is working well he knows enough to let it alone. He tries every binding screw. He studies cause and effect. He does n't have to learn a thing twice. If he makes a mistake, he thereby learns a lesson. If he is on a trouble, he won't leave it because it is five o'clock. He knows just as much about induction coils as the next man, but they don't trouble him in business hours unless they happen to be inside of a transmitter. When

he walks the street he keeps one eye on the wires, and does n't fail to report any defect he sees; and it does n't take him a month of Good Fridays to get acquainted with the lines of his own employers. A subscriber who has once seen him wants to see him again, and the linemen, who secretly hold inspectors in contempt, always like to be on a job with John. He does n't report a cross until he knows it is one. He does n't report the line open until he has tried the receiving telephone to speak with, and before rejecting a transmitter he will examine the battery and bell connections. In a word, he is thorough, and to all inspectors I say, *be thorough*, whatever else you may not be. A word to the wise is sufficient.

It is not likely that any but the latter class of inspectors will be advertised for for some years.

THE TELEPHONE INSPECTOR: HIS DAILY WORK.

Nearly all telephone exchange companies have on their pay-rolls a class of employés who, by common consent, are denominated "Inspectors."

In a prior chapter I have delineated several types of this interesting genus. Although universally classified by the name of "Inspector," inspection usually and rightly forms but an inconsiderable fraction of the duties devolving upon them. In exchanges located in the smaller cities and towns, where a perfectly organized corps of employés is necessarily, on the ground of economy, a practical impossibility, the duties usually falling to the lot of inspectors must, of course, be performed by the general utility man, who may combine the offices of line-man, battery-man, inspector and general constructor. He will for our present purposes come under the third head. It is a very difficult thing to lay down a series of iron-bound rules for the use of inspectors in a business where so much depends upon the exercise of discretion, and yet it is, on the whole, better to provide a system of rules, as an inspector who is worth anything will have sufficient sense to break them if a really necessary case comes up.

The duties of an inspector should be to examine regularly and at stated intervals the apparatus—including bells, telephones and batteries—at each subscriber's station, as well as the leading-in wires; and also, as far as practicable, the line wires. He ought, moreover, to

make himself perfectly acquainted with the direction in which the line wires run, such a knowledge assisting greatly in the localization of line troubles. He should be able to perform necessary repairs, and, remembering that an ounce of prevention is worth a pound of cure, should be careful when inspecting any apparatus to leave everything pertaining thereto in the very best condition, so that there will be no likelihood of any trouble occurring there between visits. An important part of his business is to discover promptly the cause of any trouble which may manifest itself, and, when he has discovered it, to know that it is the right cause. He should never touch, disarrange or readjust any instrument or portion of apparatus, until he is sure wherein the trouble lies. It is necessary also for him to know when to leave anything alone, and this is, in many cases, the most difficult thing for an inspector to learn.

To leave everything else immediately when any trouble is reported upon a circuit, and to locate and, if possible, remove the trouble before leaving it; to report faithfully the nature and cause of the trouble, and to suggest means to prevent its recurrence; and to become thoroughly acquainted and familiar with the central office, especially the switch-board and all appliances connected therewith—so that when an emergency arises, he shall be competent to assume intelligent control of the office, or in the event of any defect occurring there, he may be able at once to find the trouble and remove it—should be the aim of every inspector.

Many other duties will, of course, be laid upon the inspector from time to time; but the above will probably form his daily work.

In the accomplishment of his diurnal inspection, he will find it frequently necessary to make slight repairs at a subscriber's station. He may often have to change the instruments and to adopt temporary remedies for electrical defects. It is, therefore, advisable that he shall be supplied with convenient tools and instruments, whereby his work may be expedited and his time economized. The following articles will all be found useful; many of them indispensable: First and foremost, the "pliers" (if only one tool is at hand, let it by all means be a pair of pliers with cutting edge); a small, well-tempered screw-driver, a pair of tweezers, an infinitesimal oil flask and a coil of magnet wire. Without these tools the inspector should never take his walks abroad. It is always prudent to carry a Leclanché zinc or two; a couple of packages of sal ammoniac; half a dozen or so of one inch and inch and a quarter blue screws, and a paper of double pointed tacks.

It is well that inspectors should know what they are expected to do, and that when they do know they should be required to do it.

Those exchanges wherein all the employés are made to feel that they have an interest in the success of the system, and in which the employer takes an interest in the well-being of the employed, are invariably the most successful in operation. I know of several exchanges

where, every week, the superintendent gathers together his office managers and inspectors, and each man details his week's experience and compares notes with every other one. If any employé has found cases which he has not clearly understood, or thoroughly mastered, he describes the case and it is discussed, much to the benefit of all concerned. The idea is an excellent one and should be universally carried out.

Seeing that "order is heaven's first law," it is well to lay down such rules for the ordinary guidance of inspectors as may in each case seem proper. For want of better the following are suggested:

Each inspector to be promptly on hand at the regular time, whatsoever that time may be.

A complaint book or bulletin-board to be kept on the office table, or where it may be at all times accessible; inspectors to be required to examine the book every morning before going out, to see if any complaint has been received over night.

Previous to starting on a regular inspection route the inspector must ascertain from the office manager if any circuits have been noticed out of order; should there be any, he must attend to that trouble first.

Every inspector should be required to see all his subscribers' instruments at least once in two weeks, and upon every visit should ascertain from the subscriber what the condition of the service has been since the last visit. In case of any specific trouble being mentioned, in addition to testing for the same, it must be reported at the office, that the cause may be fully investigated.

(It will often be found that complaints of a general character arise, as graphically stated by a Western exchange manager, from "pure cussedness" on the part of the subscriber. It will never do, however, to say this, or even to intimate as much.)

Inspectors should be required to keep every part of the telephonic apparatus perfectly clean, and, to aid them to this laudable end, they should be furnished with a small soft-haired paint brush, with which to brush off accumulated dust.

They should be required to test thoroughly each instrument inspected, which may be done as follows: On entering the subscriber's office, the inspector should first brush away the dust from the instrument, and, with a cotton cloth carried for the purpose, otherwise brighten up and clean the apparatus. He should then try each screw-post, to see if they are perfectly tight. He ought also to look carefully over the ground wire and see that it is well fastened to the ground connection, whether it be gas or water pipe.

He should look in the battery box and try the battery connections; scrape off any accumulated salts that may have gathered around the jar, and see if the zinc is intact and if all the sal ammoniac is dissolved. Of course, any loose screws must be tightened. Any zinc worn nearly through should be taken out and replaced by a new one, and if the liquid has no sal ammoniac in it, about half of an ordinary package should be put in.

Having done all this, then and not until then, should he call up the central office, and thus test the calling

generator. If a prompt response be obtained, he will thus know that the calling apparatus is in good order. The time taken to get a response should be noted and, if unreasonably long, reported and the cause ascertained. He should then desire the central office to signal the subscriber's office, and thus test the alarm apparatus or bell. The telephone and transmitter will, of course, have a practical test by the necessary conversation.

If all be well, he may then pass on to the next subscriber, giving, as he leaves the office, a look at the entering wires, both inside and out.

It is now evident that there is a positive advantage in giving the whole apparatus a rigid scrutiny, and in fixing any loose screw, defective battery or other apparent trouble before testing the operation of the instrument. Many troubles can thus be detected and removed which, were actual operation alone trusted to, would not always manifest themselves then, but would appear at some early period; and, even though they did affect the present operation, would necessitate more than one call to the central office, thus wasting the time of both inspector and operator.

In the event of finding some part of the apparatus out of order, he would, of course, not leave that place until the trouble should be removed, or, in any case, until the instrument should be put in temporary repair.

No inspector to be allowed to adjust or disarrange any part of the telephonic apparatus, except for the removal of a fault, and then only if he knows where the fault is and in what it consists.

If any inspector shall incidentally see the instruments of a subscriber which are under the care of any other inspector, and shall ascertain that they are in any way out of order, he should fix them to the best of his ability, and report the case and his action thereon, on his return to the office, to the proper inspector.

All inspectors ought to know the telephone wires, and if while passing in the streets he should see any that are out of order or in a dangerous condition, he is to report the matter to the proper department; or if he shall see any telephone wire lying broken, he is to make a temporary splice with office wire between the two broken ends.

Should an inspector happen to be engaged outside upon any case that takes considerable time, it will be his duty to report his whereabouts frequently to the central office, so that he may readily be found in case of trouble.

Regular inspection work must be dropped in order to respond to a complaint from a subscriber, and circuit troubles shall take precedence of all other complaints.

Other and probably better rules, and more of them, are doubtless in force in many exchanges, but the proper observance of the above will tend toward good work.

THE INSPECTOR ON DETECTIVE DUTY.

The recipe given by Mrs. Glasse for the proper method of cooking a hare, commenced, as is well known in modern history, with the immortal sentence, "First catch your hare." These words, slightly modified, should be embroidered in letters of gold upon the cardinal red lining of every inspector's hat. They should there be made to read, "First catch your fault." All telegraphic, telephonic or other systems of electrical communication will, in the nature of things, develop faults and defects in working, irrespective of the care or expense involved in construction.

Not all such organizations, however, are brought into such intimate relations with the general public as the telephone exchanges. Even the gold and stock printing and the district telegraph systems can bear no comparison with the telephone exchange in this particular, because the former deals exclusively with a class of intelligent business men, who are acquainted with the propensity of all machinery to get out of order, and realize that if an instrument is intended to accomplish an ingenious result, it will probably be sufficiently intricate to possess machinery requiring care and attention. Moreover, the very complication of the stock printer has frequently frightened away from it the meddling amateur, who works so much woe to the Blake transmitter and the magneto bell. It is also evident that the limited use of the stock printer calls for the employment of a smaller number of inspectors, and

consequently a much stricter watch can be maintained over them, and a higher class of inspector be readily maintained, while a sufficient number can be always provided to exercise a careful supervision over each individual instrument.

Or, take the case of the district telegraph instrument. It is true that its numbers are legion, but its scope is limited and its use correspondingly so. As it can do but little, its internal arrangements are of the simplest character, amounting only, ordinarily, to a circuit breaker, which may be rotated once, twice or thrice, according to the required signal. Any trouble affecting this instrument, or the circuits employed in connection therewith, can be readily localized and removed by almost any intelligent person understanding the system.

But the telephone is not in every case subjected to the rules to which we have been brought up. A heavy escape that will completely incapacitate a line of printers will scarcely affect the magneto bell, and will actually improve the operation of a set of telephones.

In the operation of a telephone exchange, we hear all kinds of voices—the hoarse, gruff voice of the warehouse-man; the sharp, imperative baritone of the merchant; the incisive clearness of the lawyer; the dulcet, feminine voice of the young lady at home; and the Bowery slang of the office boy.

All these voices have corresponding pairs of hands and curious eyes attached to their organizations; and all the owners of these same attachments have a vivid

consciousness that by turning a screw like this and pressing a spring like that they can materially improve the working of a telephone.

Not the least, by a geographical league, of the troubles that beset the path to glory, as daily trodden by the telephone inspector, is that thorn in his flesh—the amateur electrician—and any patent covering a feasible method for his extermination would prove as valuable as the celebrated Page patent or the Simpson gutta-percha monopoly. In responding to a complaint of defective service, therefore, the inspector must never be oblivious to the fact that the trouble may be caused by the subscriber himself and must, while not forgetting his courteousness, be prepared to take steps to prevent the recurrence of the trouble.

It is not always easy to decide from the nature of a complaint what the character of the defect is. It is usually the same thing to the subscriber. It is only when the defect is well defined that he gives any guide in his complaint. It should, however, be the aim of both office manager and inspector to forestall complaints as much as possible, and, to that end, the most complete harmony should be maintained between the two departments. Any inharmonious relations between them would, with me, were I a telephone superintendent, be sufficient cause for the removal of either the office manager or the inspector, as the necessities of the case might warrant, to another sphere of action. We will now imagine an every day case in a telephone exchange.

Excited subscriber comes in, saying, "What's the matter? I have been ringing this hour, and can't get an answer."

That's the idea. The subscriber has given the cue in his first three words. "What's the matter?" All we have to do is to go ahead and find out, remove the trouble and report.

A small percentage of men will do these things in the proper order; a little larger percentage will do them, only putting the first last, and the remainder will omit the first item altogether.

"Well," I hear some one say, "it's easy enough to talk; but what would you do in the premises?" I would, first of all, if I were an inspector who had no previous electrical experience, find out just how certain troubles would affect the instruments; but in the present case it is evident that the first thing to do is to find out what the defect is.

1. Ask the office operator to ring up the complaining person and await results.

She may say, "He does n't answer."

Very well; but if the office annunciator armature vibrated you have, at least, ascertained that the line is not broken. If, on the contrary, no result was apparent at the central office when the call was made, it is equally evident that the line is open somewhere. Or, in the third place, the call may have succeeded and the subscriber responded by telephone.

Take the first case. The subscriber does not answer, but the armature operated by the calling current vi-

brates. The signal may have been given at the subscriber's office, but no one was there to answer it; or an escape may be on the line, or a ground or cross may be similarly located. We may safely conclude, in this case, seeing that the result corresponds with the subscriber's report, that the first idea may be neglected and we can proceed upon the hypothesis that a ground, cross or escape is somewhere on the circuit, either in the central office, on the line, or in the subscriber's office.

Going now to the subscriber's office, the inspector may take a look over the apparatus. He may perhaps find, as did the writer once in a hardware store, a crowbar leaning against a line binding-screw and the steam heater. More likely, however, he will see nothing amiss, and upon turning his crank, if the bell be a crank magneto, will find that it rings all right but that no response is made. Let him then disconnect the line wire as it enters the building. This done, if the bell will not ring, the trouble is outside. If, on the contrary, the bell does still ring, the trouble is a ground and is on the subscriber's premises, and must be sought for there until found and removed. A careful search will generally reveal it, but if it is difficult, the wire may be severed again, about half way beween the former break and the instrument, and the ringing test once more applied. When the defect is found, the breaks must be carefully repaired.

If the trouble is ascertained to be outside and there is but one subscriber on a line, the inspector can now

return to the office and proceed to the cupola or other entering point. He may disconnect the offending wire there and ascertain if that opens the wire to the switchboard. If the wires have been properly run inside they will probably be clear, but I have known copper joints made in a hurry and carelessly wrapped, come together behind a switch and ground lines. But we find that the drop armature no longer vibrates, and we have, therefore, ascertained the trouble to be on the line wire between the central office and the subscriber's office. The case may now be turned over to a lineman, who has only to go over the line. In case more stations are on the line, operations are, of course, much simplified, as it can be ascertained in the same way between which two stations the trouble is. No. 3 cannot get central office. You open at No. 2 and No. 3 can still ring his bell ground between No. 2 and 3.

Take, now, the second case. Complaint was: "Can't raise central office." Operator there tried to call subscriber, but tried in vain. The armature of the central office drop does not even move. All nature unites in telling you that the line is either open or has a very high resistance in it, such as a loose connection. As in the previous case, the defect may be either at the central or sub-station or on the line. You are at the central office; there is only one station on the line, and that is half a mile away, so it is evident that in this case charity begins at home and you test the central office part of the line first. If you have a spare battery, say of four or five cells, it is a good plan to disconnect the

end of the line from the ground plate and connect it with this spare battery, connecting the other pole of the battery to a ground wire. You will thus have a steady battery on your line and avoid troubling the operator. Supposing, however, that you have no such battery, connect the wire just where it leaves the building to a ground wire and see whether, upon sending a call, the armature now vibrates. If it does, all right; the break is outside. This test can be performed without the assistance of the operator, by inserting a magneto bell between the office wire and the ground wire. It is a good plan to keep a bell in the cupola always for such work.

If, upon grounding, the bell does not work, the trouble is in the office, and can be found by inspection, aided by the application of the ground wire, as before. If the bell does work, the trouble is outside; and if but one station to the line, the inspector proceeds thither, and carefully examines every line connection screw-post down to the ground wire. He may find a loose screw-post, a wire broken by carpenters, or a missing gas meter. If so, all there is to do is to fix it in good shape; and be sure that the ground is made on the water pipe or that the meter is bridged by a stout wire.

If everything appears to be all right, he will ground close to where the wire enters, and try the bell, proceeding just as at the central office. If the bell rings, fault is outside; if it does not, trouble is inside, and must be found by continued inspection and grounding. If proved that the trouble is outside, and there is only

one station on the line, report to lineman line open. If other stations are on the line, proceed as before, and when the break is thus localized between two stations, a temporary ground wire is put on, so that as many stations as possible may be grounded in.

Take next the third case. The call made by the central office operator was heard by the subscriber, and responded to by telephone. What now do the circumstances indicate? First, that the central office signals reach the subscriber, though those of the latter do not reach the central office; secondly, that telephonic conversation is practicable in both directions. This, then, proves that the line is not broken nor heavily grounded or crossed, and also that the talking circuit is complete at the subscriber's office; and the cause of trouble is probably located either in the annunciator at the central office or in the calling apparatus of the subscriber. I say *probably*, because it is quite within the bounds of possibility that when the subscriber is now called upon to try and signal the office, he finds he can do it all right —the trouble was transient, and was produced by lineman drawing wires over or temporarily disarranging the wires. The subscriber is requested to try to call the office, but no drop falls. The drop is examined and may be found to have a wire-edge on the detaining latch or some other little mechanical difficulty, which, when attended to, removes the fault. If the drop is found to be in good order, the subscriber's calling generator must be examined, and upon a careful examination will probably show at once the cause of the defect. The friction

wheels perhaps slip; or the belt is broken or stretched; or a leading-out wire broken from the hinge of the box, or it may even be ascertained that the subscriber has thought fit to take off the telephone, and thus has opened the bell circuit before he commenced to call.

It must not for a moment be thought, because it takes so much time and so many words to explain these proceedings, that an equal length of time is occupied in the transaction of corresponding deeds. Every movement made for an accurate preliminary test frequently saves an hour of happy-go-lucky trouble hunting. Whatever thy hand findeth to do, do it with thy might.

Having now followed our inspector through the work of testing for and ascertaining one kind of trouble, we may hope that the irate subscriber was duly satisfied with the result of the investigation; yet it is proverbial among electrical inspectors that, when trouble once commences at any particular place, it is invariably well followed up by others. In the words of Sir Boyle Roche, "the greatest of all possible misfortunes is inevitably followed by one which is much greater." So we may, without stretching the bounds of probability, imagine the same much-afflicted subscriber returning, precisely a week from the date of his former complaint, with the contemptuous remark, "That thing worked all right for two days, but it is out of order again."

Courteous manager blandly inquires: "What is the trouble now, sir?"

Irate subscriber: "Oh, I can call you first-rate and I can hear you talk, but I can't make you hear me,

Guess you had better take the instrument out, if it is n't going to work any better than that."

Here the manager has a chance to show what he is made of. If he is a judge of "human natur," as Deaf Stapleton used to say, he will let the subscriber talk until he has about talked his indignation away, and then he will simply respond that he will have it attended to at once, or words to that effect. If he is not a judge of human nature, he will try to persuade the irascible gentleman, against the evidence of his own senses, that the instrument is all right, and that it was only the said irascible gentleman's inefficient manipulation that was at fault.

But, as a matter of fact, in a case like this, the chances are ten to one that the office operator detected the trouble before the subscriber did, and that by the time the complaint is made, the inspector is already on the ground and examining the instruments.

It will be remembered that the complaint was that, although the subscriber could hear from the central office, he could not make the office hear him. It is obvious, therefore, first, that the receiving part of the subscriber's apparatus is all right; and, secondly, that the transmitting part is all wrong. The zealous and thoughtless inspector now invariably jumps to the conclusion that the Blake transmitter needs adjusting, and forthwith opens it, catches hold of the carbon button with his fingers, snaps it vigorously up and down a dozen times or so upon the platinum electrode; then, warming to his work, he pulls out his screw-driver and

gives the adjusting screw four turns ahead, and three and three-quarters turns backward, just as if the transmitter were a safe, and four one way and three and three-quarters another were the combination thereof; next he gives the carbon half a dozen more ferocious snaps, closes the door, and after bawling, "How do you get me now," into the mouth-piece in stentorian tones, reports the affair O. K., and returns to wait for another victim. Thus proceedeth the zealous and thoughtless! Is that the way all inspectors do? Not so; yet the picture is not overdrawn, for I have seen the foregoing proceeding fully carried out many times, and am still totally at a loss to imagine the ghost of a reason for the carbon-snapping part of it; a feature which, with this class of inspector, is never omitted.

The zealous, thoughtful and efficient inspector does *not* take it for granted that the transmitter needs adjustment; and if he discovers, after due investigation, that such is the case, he goes about it in an intelligent manner. Many of our most promising inspectors, however, are young and inexperienced, and with a hint or two will do well; and, again, the old rule comes in, "Be sure you 're right, then go ahead."

Several causes might result in the trouble which caused the complaint, and it might as well be admitted here that its most probable location in this case is, indeed, somewhere in the transmitter. The same symptoms were on one occasion, however, found by myself to originate from a cause completely external to the transmitter. In the instance I refer to, the trouble was

caused by the bad workmanship of the construction fiend, who, seized with a fit of economy, either of double-pointed tacks or elbow grease, had brought the two line wires leading into the secondary coil of the transmitter together, and then tacked them so tightly down under one staple as to virtually short-circuit the secondary circuit of the induction coil, so that no currents generated in it could pass to the line. It, therefore, pays to stop and think, before altering a single adjustment, how many conditions might cause such a difficulty as we have under consideration; after which it is time enough to decide what is the condition in the particular case.

Let us remember that a Blake transmitter is a compound instrument. It has comprised in its little black walnut box two distinct circuits—a complete local circuit, passing in from one pole of the transmitter battery to the variable resistance contact, thence to the primary or first circuit of the induction coil, and then out and back to the other pole of the battery; and a portion or loop of the line circuit, which merely comes in, passes through the secondary, outer or fine wire coil, and then goes out again. The current steadily flowing through the primary coils is made alternately stronger and weaker, as the contact between the carbon and the platinum, under the influence of the diaphragm when operated by the sound waves of the voice, becomes firmer or slighter; and at every variation in the strength of the current, a current is set up in the surrounding secondary coil. If there is

no electrical current in the primary coil, there can be no currents started in the line coil; therefore, it is evident that a defective battery may cause the trouble. Following out the same line of thought, we may further reflect that, since a defective battery may cause the trouble, anything which may cause the current generated by a good battery to be interrupted will also cause the trouble; therefore, a broken wire in the primary or battery circuit will be sufficient to account for the result.

Again, it may be readily seen that if there is any connection between the two battery wires before they enter the transmitter, thus forming a short circuit cutting off the primary coil and contact points, the effect is the same; the transmitter is still dormant.

Our previously mentioned friend, the staple or double-pointed tack, used judiciously, might, for example, accomplish this effect quite as easily with the primary wires as we have seen that it did with the secondary wires. Moreover, the transmitter may be so loosely adjusted that the carbon and platinum contacts do not touch; or the local circuit-closer in the magneto bell may be out of order.

We may, then, sum up as follows: If the receiving telephone works properly, while the transmitter does not:

First—The trouble may either be in the local or primary circuit, or it may be in the line or secondary circuit of the transmitter. Secondly—If the former, it may either be in the battery itself, in the transmitter,

or in that part of the primary circuit which, to be automatically opened or closed, runs through the call bell. Thirdly—If the latter, its nature can only be that of a cross between the in and out wires, since the telephone, which is in the same circuit as the secondary coil, works; which, of course, it could not do if the wire were broken.

Now, therefore, having seen that so many conditions would all produce the same result, how shall we go to work to find out which condition we have to contend with? Test the apparatus as soon as you reach it. See if the fact is as stated. Finding that it is, that you can hear the central office operator, but that he cannot hear you, talk to him through the receiver and tell him to wait till you call again. Ascertain now whether your battery is all right; first, by ocular examination, then by tasting. You may at once see that the wires are eaten away or otherwise severed, or you may see that it is dry. In one case, repair the wire; in the other, wash out the glass and fill up with new solution. Test again by talking, and you will probably find everything all right. Suppose, however, that the battery looks all right; you then unscrew the battery wires, so that you have one direct wire leading from the zinc and one from the carbon, and taste the ends; if, on putting the end of both wires in your mouth, you taste the current fairly strong, you must look elsewhere; the battery is all right. If, on the contrary, you taste nothing, or almost nothing, the battery is most likely the seat of the defect. Clean the zinc; see that the

sal ammoniac solution is strong enough; see that the gas holes in the top of the porous cup are clear, and ram them through with a small screw-driver; see also that the connections of the leading-out wires are well made, and that there is no white lead around the cap of the carbon. Your battery will, most likely, now work up. If it does not, change the porous cup.

But suppose the battery had proved, both by examination and taste, to be all right, your business is now to find out if the defect is in the magneto bell or in the transmitter proper. Open the transmitter and see whether anything wrong can be seen; this, by the way, may be done first, as it takes little time and sometimes saves work. You may possibly find the electrodes or contact points apart. If so, carefully adjust them according to the instructions given in the chapter devoted to the Blake transmitter, and again test. If everything looks right, unscrew the wires from the primary circuit binding screws of the transmitter, and with the telephone *off* the hook, again taste; it is to be observed that the battery circuit is now longer than when you tasted it before, as it passes through the automatic circuit-closer. If you get the taste again you must look further, the fault is not in the circuit-closer. If you do *not* get the taste, you have localized the fault inside the bell box. It can, in that case, only be a bad spring contact or a broken wire, and upon opening the box may be easily found and repaired.

We will suppose, now, that the taste was present and that we must look into the transmitter for it.

There, if the electrodes are close, as we have already by ocular examination seen they were, the trouble must be a broken wire, an oxidized screw connection, or a defective hinge connection; the adjustment seldom has anything to do with this trouble.

If everything in the primary circuit is in good order, closely examine the secondary wire, both in the transmitter, out of the transmitter, and in the bell box, for a cross between the two wires. Any such trouble will generally be found in the local circuit, and the secondary need only be examined when everything else fails to show the fault.

An inspector with a good sense of taste might simply open the primary circuit, first taking the telephone from its support, and taste the two open ends, to ascertain quickly whether the fault was in the primary or secondary circuit.

But as the primary object of this chapter is the instruction of the junior inspectors, it has been thought well to describe the testing operations at a step-by-step rate of travel. As a concluding aphorism I would add: Try to find the fault with your eyes before testing in any other way, or before touching the apparatus at all.

THE DAILY ROUTINE OF THE TELEPHONE INSPECTOR.

As a rule, when a subscriber to a telephone exchange calls the central station, he wants his line connected to the line of some other subscriber for conversation. The rule is, of course, not without exception, since cases are upon record of subscribers signaling the central office just to see if they would be answered; of others ringing up and then paying no attention to responses from the office, while at least one case is known to have occurred where a mischievous office boy, "too smart for anything," used to call the central office and request to be connected, for example, with No. 135. When put in communication with 135, he would say, "Who are you?" and when answered "135," he would add, "Well, I don't want 135," and disclaim all desire of conversation with that subscriber; and, after accomplishing a disconnection, he would continue the interesting game by calling for another victim.

Such boys can raise an incredible amount of ill-feeling and dissatisfaction between central station and subscriber; though, if well supervised and kept at the right kind of work, they have a good chance to make a name for themselves sooner or later. But these are exceptions, and the rule, as previously stated, holds good. It is, therefore, very provoking when a subscriber calls a central station to find that he can receive no response or hear nothing at all. It is equally annoying for a central office operator to see the shutter of the

annunciator drop again and again, and after each time faithfully answering the call, find that not a word can be received from the person calling. In practice this is found to be frequently the case. It also happens that a subscriber is wanted by some one else, and when called by the central office, although he honestly endeavors to answer, he finds that his transmitter is dumb and his microphone deaf.

It has occurred that some subscribers have become negligent in replying to calls, even saying, "It is only the telephone; they 'll ring again." This, however, is an abuse that should not be tolerated for a single day, and which is generally easily cured by the prompt action of the exchange.

There should be an inflexible rule in this matter, that under no circumstances shall a subscriber be called more than twice, or three times at the outside. Such rules have, it is understood, been adopted in many of the larger city exchanges. All parties soon learn then that to answer promptly is just as much a duty of the subscriber as of the exchange. It has hitherto been customary for the subscriber to exact the utmost courtesy, forbearance and time from the exchange, without in many cases regarding such characteristics as being reciprocally due from him.

The foregoing rule can, however, be rigidly enforced without any neglect of courtesy, and when any reasonable man is shown the necessity for its enforcement he will coincide in its fairness.

When the subscriber calls the central office and can-

not converse or hear what is said, it is at once evident to the operator there that something has gone wrong; when, however, the office signals the subscriber and fails to get a response, we can by no means be so sure; but it can never do any harm to send and ascertain in either case.

It will for our present purpose be supposed that the subscriber has performed his part of the contract. He called, or he has been called, and he has gone through the motions of answering, but, in the English of the patent lawyers, he has failed to "effectuate" any useful result. He does not often experience trouble in manipulating his telephone, so he calmly hangs up the instrument and awaits developments. In the course of half an hour, if the exchange manager and inspector are up to the exigencies of the business, in walks the latter official, armed with a pair of pliers and a screw-driver, "even these, if nothing more." The trouble is a very simple one to find, and yet it is too true that many men, even in this case, would at once do everything but the right one.

As in prior cases, the best way is to look at the apparatus first with both eyes open. If looking discovers nothing wrong, try to get the exchange and find out whether in deed and truth both transmitter and receiver are alike affected. It turns out that they are. It would be well then to find out two things—first, is the station a way or terminal one; second, if the latter, if the same ground wire is used for the bell branch as is used for the telephone, Why? Because, if the

station be an intermediate one, the trouble is likely enough to be due to the disappearance of the ground wire.

This I have frequently seen. The trouble does not show when calling, because then the circuit is completed from the ground at the end of the line. Neither would it if the telephone were included directly in the line circuit, because then it could also work on the terminal ground. But the fact is that at an intermediate station there will probably be a secrecy switch, and the use of that contrivance renders it necessary that a ground wire should be used for the telephonic circuit at each station, so that when the subscriber turns his secrecy switch in either direction, one side of the instrument is opened and the other put to a ground wire through the telephone and transmitter.

When, therefore, this trouble occurs at a way station, the ground wire ought to be the first thing looked to. The gas meter may have been removed or the wire cut by carpenters or amateur electricians. This, again, is the reason why it is well to find out, at a terminal station, if the bell and telephone branches are connected with the same ground wire. If they are not, the fault is likely to be a lack of continuity in the ground wire. If they are, we see at once that the trouble cannot possibly be in the ground wire, as, if enough current can be produced on a line to drop an annunciator, most certainly enough can be produced to work a telephone.

But we will suppose the ground wire to be in good order. We must then look elsewhere for our trouble.

The best way to begin is at once to disconnect the transmitter—that is, the two left-hand wires, which are the secondary coil or line wires, and pulling them out, splice them together. Then call the central office again and try with the receiving telephone whether communication can be effected, now that the transmitter is cut out. The test is easy but sure. If the telephone works and you can now talk to the central office, it is very evident that the trouble is not in the telephone, but in the secondary coil of the transmitter. If, on the contrary, the telephone remains deaf and dumb, the fault is not in the transmitter, but in the receiver itself, the flexible cord or the bell connections. We will assume that the telephone did work, showing the transmitter to be the culprit.

If the fault thus localized can be easily seen, it may, perhaps, be the best to fix it then and there. It must, however, necessarily be either in the induction coil, the binding screws, or the wires connecting the secondary coil with the binding screws. If in the coil, the quickest way is to change the instrument at once, and put in a new coil on getting it to the office (where relief coils, by the way, always ought to be kept). If in the leading wires, you can generally see it on close examination, or by a little pulling it will part, when it can be spliced by a short piece of wire from the wire reel, which some inspectors never carry with them and which others always do. If in the binding screws, take the blue screws completely out, and it will probably be seen that the washers are covered with dry acid and corroded, or

it may be found that the wire is corroded at the point of junction.

It is now time to consider the other alternative—the telephone declined to work in single harness. See whether the screw-posts are tight. Connect the flexible cord to the battery by one end and tap on the other battery pole with the other end. See if that makes a good snapping sound in the telephone. If it does, the telephone and cord are all right, because, as both transmitter and telephone were dead, the fault is certainly a circuit trouble, and, therefore, no mechanical fault pertaining to the telephone alone can be considered; such, for example, as a weak inducing magnet, or a sticking diaphragm.

There now remains only one suspected spot, namely the bell and its connections, so it must be opened and its internal arrangements examined. These are very simple, and it will scarcely take a minute to make all the inspection required. A spring may be bent or a contact dirty, or the retracting spring of the automatic switch may have lost its elasticity, and does not pull the switch far enough back to make contact at all. These evils, any or all of them, are sufficient to cause the trouble and must be looked after and removed. Having removed them, let our inspector look around and see if anything else needs attention.

If a battery requires water, let him give it. If a zinc be worn out, let him change it. If the office wires are hanging in graceless festoons and flying trapezes over the walls, let him, if consistent with his duty,

tighten them up, or, if not, note them and report to the proper authorities for attention. Let the inspector, in short, never suppose that he will destroy his own chance for bread and butter by the lack of complaints or circuit troubles, as the difference between a profitable and an unprofitable inspector consists chiefly in the fact that one not only faithfully responds to, but also removes the cause for complaint, while the other, by his laxity, provokes complaints, and, by his incompetency or laziness, neglects them; and thus not only provokes the complaint, but finally provokes also the complainant. *Verbum sap.*

INDIVIDUAL CALLS FOR TELEPHONE LINES.

Although the telephone is, perhaps, the simplest instrument ever developed by the brain or constructed by the hand of man for electrical communication, it is very apparent that certain accessories, both before and after the fact, as it were, are essential to its success as a factor in business and social life. Since the telephone itself cannot generally speak sufficiently loud to notify its patrons when a message is about to be sent (nor, indeed, is such a state of affairs desirable), it was seen at a very early period in telephonic history that some calling or signaling device was necessary. The telephone was first introduced on private lines, usually of limited length, and generally with but two stations, one at each end, which were already built and fitted with Morse telegraph instruments. The Morse instruments were, therefore, utilized as the first telephone calls. It soon became evident that a degree of skill was requisite to work the Morse keys and sounders thus used, and that unless some more popular method of signaling were adopted, the onward march of the new invention would be checked, and the little giant would remain a stunted dwarf. The result of this was a great increase in the number of electric bells manufactured, for any one could readily notice the silvery tone of the single stroke, or the imperative rattle of the vibrator, even when the monotonous rhythm of the Morse sounder would pass unheeded; and so on the before-mentioned

private lines the bells succeeded the sounders, the sounders were laid on the shelf, and the telephonist was once more happy and contented. But only for a short time; for soon it was seen that the number of stations on a private line could not be limited to two; and when that number was largely increased, the constant ringing of bells, melodious as it might be *per se*, and sweet as the Bells of Corneville, yet became a trifle monotonous, and once more the wearied ear yearned for rest and silence.

Moreover, the telephone exchange system by this time began to rise into view, and it was then considered pecuniarily impossible, or at least undesirable, to have individual lines, or, indeed, less than five or six stations on any line. The projectors of the primeval telephone exchanges were or had been telegraph men, and the system they inaugurated was naturally a system of calling consisting of single stroke bells on a closed battery, the ringing being accomplished by breaking and closing the circuit the requisite number of times; and the number of stations on each line varied from four to over a dozen. It is obvious, as stated above, that when such a number of stations were placed in circuit together, if much business was done on the circuit, the ringing would practically be perpetual and no peace or quietness could be obtained. Still, it was found that some persons liked the continual jingle, even those who might be supposed to be troubled the most by it.

An example on the point is the following, which came under the writer's personal observation: A reverend

gentleman was a valued subscriber to a telephone exchange in one of the smaller cities in Massachusetts—his telephone and bell being placed in his study—and was located in one of the busiest circuits. The exchange manager at length took pity on the clergyman and offered to place him on a quieter circuit. To his surprise, however, the minister declined to be transferred, saying that he did not mind the jingle; that he rather liked it, if anything, and in fact never noticed it. He was, of course, not transferred. But when the astonished exchange manager related the circumstances to a mutual friend of himself and the divine, he was greeted with the dry remark: "Perhaps he does n't mind it, but it is very perceptible in his sermons." This gentleman was an exception, an honorable exception, perhaps, but still an exception, and a demand, which is ever the pioneer of a supply, sprung up for an individual signal.

It is proper here, for the benefit of the uninitiated, that the term individual signal should be defined. It signifies literally a means for calling the individual. That is, in a circuit of say six stations, at the will of the operator any one of the six can be called without signaling or attracting the attention of the others. It is not the least of the wonders of the telephone that it has given an impetus to so many branches of electrical invention, and this branch of the "individual call" has been the most prolific, bore early fruit, and is still bearing. After the early demand for such a call-signal, it came to be seen that on the busy lines of our large cities, one, or at the most two, stations only could be

practically operated, simply because when more than that number were placed on a line they were continually getting in each other's way. But on the social lines in suburban districts, or in exchange systems in the smaller cities and towns, prices could not be raised as they were in larger places, and it was, therefore, found necessary to do one of two things, either submit to the constant ringing or find an individual bell or call that combined all the requisite virtues—one that was cheap and good, simple in operation and sure in result, one that could be depended upon to call the right man at the right time, and, what is equally important, one that would not call the wrong man at the wrong time; and, finally, one that was simple in construction, would not easily get out of order, that when out of order could be readily fixed by the exchange managers, who frequently were anything but *au fait* at such work, and one that was cheaply maintained. Nothing answering these requirements was then in the market, but the demand was seen and the result was that the inventive genius set to work, and up to the present time some fifty patents have been issued on this one subject.

The essential points that every individual signal instrument should possess are the following:

1. They should be able to call up the station required.
2. This must be done to the exclusion of all the other bells or stations on the line.
3. When a station is to be called on a line and other stations are between the station calling and the station called, those between must not be rung up in passing.

4. A union, zero, or initial point and a method for bringing each apparatus to such point, so that all the instruments may commence each operation together.

Other and auxiliary operations are frequently performed or attempted, such as a dial and index finger, showing which station is being called, or an automatic cut out, which shall cut out all the telephones except the one wanted; but such operations are not essential and, in the words of a brilliant but short-lived contemporary, "in the attempt to make these instruments self-acting, they are made self-hampered."

Having thus briefly delineated the necessary virtues of a good individual call, I will describe the several principles which have as yet, in one form or another, been universally recognized. These are, first, systems in which the features of strength and polarity are taken advantage of, employing apparatus similar to the quadruplex. It is obvious that if we have a line of four subscribers, and at each station we have a relay which, when affected by the current, closes a local circuit and rings a bell, by adjusting the relays so that No. 1 responds only to a weak current and No. 2 only to a strong one, we provide for two stations at once. If we now add two other bells, similarly arranged, but adapted only to respond to currents of opposite polarity, we provide for two more stations and secure for ourselves a system of four individual stations per line; such is one of the best methods suggested. To a practical man, this idea of employing some form of relay and a local circuit, including a bell, is more hopeful than most others.

Another way is to provide an instrument operated directly by successive pulsations of electricity, which rotate a star or rachet wheel carrying on its axis a circuit wheel, that when brought to a particular position, differing in each instrument, closes a local circuit. This step by step principle is used in many such instruments.

These were the first attempts at solving the problem. The next was on a different tack, and consisted in allowing each bell-hammer to move, but interposing a mechanical obstacle in the way of each hammer except the one at the station wanted. A bell of this class is used at West Winsted, Conn. (some sixty are in use there), and consists broadly of an electro-magnet carrying two armatures, one polarized, the other neutral. The neutral armature has a pawl, which step by step rotates a rachet-wheel, that has at one point a notch between two teeth deeper than usual. The position of this deep notch differs for each bell, and only when the deep notch arrives in front of the pawl of the polarized armature which carries the bell-hammer, can the said bell-hammer reach the bell. The wheel is brought round by successive battery currents, which do not affect the bell-hammer armature, but when the wheel is brought to the proper point, rapidly alternating magneto currents are sent which work the polarized armature and ring the bell. These bells have given satisfaction. It is, however, but just to say that their success is in a great measure due to the exchange manager at West Winsted, who is a telegraph man of no ordinary

ability, and who would certainly succeed in making any bells work that had work in them.

The next novelty presented, and one that, although patented, is still a novelty to most of us, is one that is decidedly the germ of a wonderfully good system, inasmuch as it needs no complicated apparatus, and has no wheel movement, is as follows: The bells at each station are provided with two electro-magnets, and the circuits leaving the central station are so arranged—one series running concentrically and another radially, one of each class running into each sub-station—that it is only when the key of each is pressed at the same time that the bell of the junction of the two can ring.

Soon afterward, another idea was developed. It was to have the signaling bell in each subscriber's station in a shunt or branch circuit; or, in common parlance, short-circuited, and using mechanism, either step by step or synchronous clock work, to break the short circuit at a stated time or a given number of pulsations, thus including the desired bell in the main circuit, when it could of course be rung.

Still another suggestion is to furnish each bell with an electric ground switch, a single current of a given direction throwing on a ground at each station. This, of course, cuts off all the bells except the first one. They are then restored to the line, one after another, each one locking its hammer as the next one is brought into circuit. When the desired bell is once more cut in, it is run by magneto currents.

I have thus outlined much of what has been done

in this line of invention. It is impossible, however, even now, to overstate the difficulty of making a really good bell at such a low price as shall be popular.

There is a great demand in hundreds of our smaller cities for a reliable signal of this class, and a demand which would grow if properly fostered and reasonably supplied. When an instrument does appear, satisfactorily answering such a demand, its introducer may depend upon reaping a rich harvest.

More than sixty attempts at an individual signaling instrument have been patented since January, 1879, and the ingenuity expended upon some of them is wonderful to contemplate, and for the majority it is greatly to be feared that virtue and perseverance will have to be their own reward.

TELEPHONE WIRES VERSUS ELECTRIC LIGHT WIRES.

One of the many questions which practical telephone men have to consider, and one of the most important, is: "What position shall we take in relation to the electric light companies, which are now pressing their claims to equal rights in the appropriation of the American householder's roof?" When leading officials in the telephone companies are also prominently identified with the electric light companies, the complication is somewhat intensified, because the additional conflict of prudence *versus* self-interest comes into play. It is not quite clear to what extent we can emulate the example of France and England in Egypt, and jointly occupy roofs. There has been much disagreement of electricians upon the point as to whether or not the proximity of heavily charged dynamo-electric light wires to wires used for electrical communication is dangerous to life and property, and also whether or not it is greatly inimical to telephone wires as a disturbing element, and how far its influence in that direction is exerted.

Upon one side we hear of Michael Strogoff being immolated in the twinkling of an eye by an accidental double contact with the leading wires of the generating machine on the yacht of his imperial majesty, the Czar. We hear, also, of the fate of the rash individual who, in Buffalo, desired to pool his issues with the brushes of a Brush machine, and who has now bidden farewell to all his fears, having been promptly gathered to his

fathers. We know, for our eyes have seen it, that when certain wires conveying electricity to supply luminiferous ether have come into contact with wires used, as certain patent specifications phrase it, as mediums of oral communication, the medium gets the worst of it; the collision only finding a mechanical equivalent in a butting contact between a mogul locomotive and a Central Park goat carriage.

On the contrary, we have heard from eminent authorities that it is perfectly safe to touch electric light wires, or even to touch both wires leading from the machine; one very eminent English telegraph engineer having testified that he has done so, while other gentlemen in this country have made the same assertion, giving the further statement that it made their hands warm—certainly a most natural result, since the currents of the majority of machines used for lighting purposes are of great volume and comparatively low electro-motive force. Seeing that light and heat are, all things being equal, dependent upon the current passing in a given time, it would not have been surprising if the experimenter had temporarily become incandescent.

In considering these things, we should not lose sight of the fact that electric currents used for the sole purpose of lighting are of widely varying character. Those, for example, supplying but one arc in a circuit, while requiring a considerable amount of the current, do not need much of an electro-motive force, because there is not much of a resistance to overcome. Where incandescent lights are used, arranged in multiple circuit, the

external resistance is also low, and again little electro-motive force is required.

On the contrary, if there are a large number of arc lights in one circuit, as is sometimes the case with the Brush light, the number of spaces which the current has to jump materially increases the external resistance, and, of course, a greater electro-motive force is required to drive the electricity through so many arcs, while the amount passing is no less.

Some machines also produce alternating currents, supplying them unchanged to the point of light, notably machines operating the Jablochkoff candle; and such currents passing through a man would greatly irritate his nervous system, to say the least. We may, however, pass the latter by with the above notice, as such systems are rarely, if at all, used in the United States.

From the above, we may conceive that in many cases a person might with impunity touch the wires of an electric light circuit, and even clasp both of them, provided the currents were generated for a low resistance circuit—because, even if he clasped both wires, the resistance across his body would be very great, in comparison with that of the proper circuit; and the currents, governed by the immutable rule, would divide between the two routes provided for it in inverse proportion to their resistances; thus the daring individual would get very little of the current, and the amount passing through him would vary, becoming less the farther away he got from the machine, because the alternative circuit would be shorter. It would also depend

greatly upon the moistness, dryness or thickness of his cuticle.

Should the same individual take hold of a similar pair of wires leading from a machine of higher electro-motive force—one designed, perhaps, to force its currents through twenty arcs in series—he might live to crow over it, or he might not. It would be quite possible that, if the lamps were not provided with automatic shunts, a sufficient modicum of the current would pass through him to weaken that passing the lamps. One arc, perhaps, would go out for an instant, or other contingencies might arise which would send the entire current through the aspiring electrician; and though it would, of course, be greatly reduced in strength by the resistance of his body, in all probability the experiment would be so satisfactory that no second trial would be necessary. However, to the ordinary untutored and unscientific mind, it would seem that any one imbecile enough to deliberately try his fortune on an electric light circuit more than once might well be spared from the world, and that his absence would tend to the security of the Executive of the United States.

In the foregoing remarks I have assumed that the electric light wires were arranged in metallic circuit. Of course, if this is not so, the conditions are materially altered. If ground circuits were used, and any person should accidentally touch one of the wires, a pair of rubber boots might make all the difference in the world.

Referring now to the possible destruction of property by a contact of an electric light wire with a telephone

line, it has been found in practice that wherever and whenever such contacts have occurred, the consequences, so far as the telephone or telephonic apparatus was concerned, were disastrous in the extreme, for it is evident that the conditions are not the same as if a contact or cross-connection had been formed of animal tissue.

No great resistance occurs in a well-constructed telephone line, such as is usually met with in our cities, either in lines or apparatus; consequently, no inordinate amount of electro-motive force is essential to induce heavy currents to pass over such lines; and when they essay the passage through the fine wire of the instruments, it is necessarily heated and becomes virtually an "incandescent light." Not being secured in a fire-proof case and possessing generally every facility for propagating the devouring element, who can wonder that, under such circumstances, the telephone case, spool and apparatus speedily become incinerated, and if no help be at hand the fire spreads and great destruction ensues? It is true that, as yet, no extraordinary damage has accrued from this source, but it is a thing we have to look out and find a preventive for. One thing more: It is frequently asserted, and with good show of reason, that all danger of destruction from the foregoing cause is removed if the light wires are run in metallic circuit; that is, if the return circuit, instead of being through the earth, is made by means of a return wire to the machine.

With metallic circuit, the danger is certainly greatly diminished, but it is not entirely eliminated; for if a

permanent ground be on the electric light wire, all that is required to make a ground circuit is a contact with a circuit that does terminate with a ground wire, and in the case of a cross, it is surprising how quickly the covering comes off a wire.

Now, to consider the possible disturbing influence that electric light wires may exercise upon telephone lines. The fact cannot be ignored that telephone wires are greatly disturbed by the passage of electric light currents in adjacent conductors, and it is very plain that such disturbances are chiefly due to induction pure and simple—for although ordinary disturbances and interfering currents may be justly ascribed, in a great measure, to leakage, it cannot be so in this case, except upon very rare occasions; since not only are the light wires of large cross-section, and generally well covered, but the currents conveyed thereon are, even at their strongest, of comparatively low tension and have little desire to escape, if their own route is much better than other and branch circuits. When the electric light is protected as above described—and is likewise five feet, perhaps, away and on another fixture—it must be conceded that its current has little inducement to forsake its legitimate path, and that the proportion doing so must be infinitesimal indeed. Yet it is undeniable that, even under such circumstances, the interference is often of considerable magnitude, and is to be obviated if possible.

Having now presented the case, what shall we do? In the first place, the presence of electric light wires

on the roofs at all is to be deprecated. It is true that it will be claimed by the parties interested that there is no danger, and that they have as much right on the roofs as we have; but is that strictly a fact? A person may desire to have a tame wolf on his premises, on the ground that he won't bite, but his neighbors may object to it, on the ground that he *can* bite. This, though, need not be discussed, as the companies will in all probability occupy the roofs, until prevented by the strong arm of the law. The only way that telephone companies can prevent and put an end to the joint occupation is to charter the entire roof; but that is a two-edged sword and cuts both ways. So long, however, as it is recognized that there *is* danger, so long telephone men must use every legitimate method to secure themselves, for if any person is crippled or killed, or if any serious fire is caused by the presence of wires, the many-headed public will not take pains to ascertain whose wires they were.

It would seem to be policy, if an electric light company proposes to run wires over a certain route, and if that route be already occupied by a pole line (or a housetop line either, for that matter, provided its proprietors have confidence in its staying power) belonging to a telephone company, to permit them to put a wire or two on the telephone poles, rather than have them build separate supports, and this for several reasons. We thereby prevent the construction of a new line of supports over our route. Using our poles, we have a right to impose conditions; and the conditions

imposed should be: Metallic circuits; heavily covered wires, painted in such a manner that they can always be recognized; supports in every case of the stoutest character and fastened to a separate upright securely fixed to the top of the pole or fixture; wires to be placed at the top so that telephone line men may never have to climb over them, and also so that telephone wires (which so greatly outnumbering the light wires, will, of course, be likely to fall with that much more frequency) shall not fall upon them. Their location at the upper end of a separate support at the top of a pole is suggested with a view to the reduction of the induced effects to a minimum.

When electric light circuits terminate at a ground near to the terminating ground of a telephonic circuit, then the evil of absolute leakage is added. In that case the only thing to be done is either to exercise the powers of persuasion, and get the "light" people to run a metallic circuit, or to run the telephonic circuit terminal to as great a distance as may be practicable.

A good plan for adoption, where necessary, is to insert in the telephone line wire leading in and out of any building a piece of lead or other easily fusible metal or alloy; which, on the occasion of a cross with an electric light wire, would instantaneously heat up to melting point and sever the conductor.

This of course would be placed outside of the building. It is a good idea to have every one of your telephone lines, as they enter the central office, easy of access at one point of junction at least, so that in case

a cross with a "light" wire occurs at night, it is but the work of a second to disconnect that wire. This is so arranged in the Pittsburgh exchange, and has often been serviceable. The views herein presented are of a general character, but it is believed that the case is fairly presented, and may perhaps assist exchange managers in determining the relations in which they stand to the electric light companies of their particular locality.

ELECTRIC BELL CONSTRUCTION.

PART I.

Although electric bell construction and such work is not strictly speaking within the scope of these so-called "Letters on Telephonic Subjects," yet so many chances of electrical work, bell hanging, wire running, and hotel annunciator repairing offer themselves to a handy man who is on the lookout for them, that it is thought well to offer a few brief instructions for the proper manipulation of instruments, wires and batteries.

In many cities of moderate size, and even in the smaller towns and villages, numbers of persons, especially those of a technical and scientific turn of mind, would be much delighted to have their houses fitted with electric bells, or connected with their stables; and, in short, to have done neatly, perfectly and scientifically what the ordinary bell-hanging fiend (who is second among the *bête noirs* of the household only to the ubiquitous plumber) does clumsily, imperfectly and worthlessly.

An active exchange manager, who, for example, is located, we will say, in a town of seven thousand inhabitants, can soon inspire the merchants of that town with the idea that their stores and warehouses are no longer safe unless they are electrically protected from the midnight marauder; that, instead of the double bass bawl of his salesman and the high soprano squall of his saleswomen (I beg pardon, of his salesladies), as

they urgently desire the services of the cash-boy, all he wants to secure his earthly peace is the soft-toned vibrator, and that, instead of having bell-hangers' joints to come apart when the handle is pulled, and coarse unmusical cow bells to announce a stranger at the door or to summon Bridget to the presence of her mistress, or to notify James to harness the horse, the very acme and quintessence of earthly happiness would be attained if they would only consent to adopt the press button as their swift-footed Mercury; the battery in lieu of the muscular force of the arm, and the electric wire in place of the mechanical wire. Having once brought the community to such a belief, it is a short step to the further conviction that the said exchange manager himself is just the man who can work these wonders, and harness the lightning to do the work of the kitchen maid. It will not do, however, to force such a conviction if unprepared to back up words with deeds.

The construction of an electric bell system, though apparently a formidable thing for an inexperienced person to undertake, is one of those enterprises in which difficulties rapidly disappear when boldly met and attacked, even as the morning mist vanishes before the noonday sun; and when any telephone man can add such work to his telephonic service, and shall devote a certain modicum of his time and money thereto, if he make up his mind to do it well and really does do it well, he may count upon what the physicist calls an admirable example of the conservation and correlation of forces; the chiming and ringing of the bells which

he sets up rapidly being transmuted to a similar jingling and ringing of cash in the pocket.

Now, to establish a bell ringing system, we must have a battery to supply the force, wires to conduct it, bells and annunciators to make it apparent, and circuit closers, directors or changers to apply it.

In all bell systems for houses use the Leclanché battery; it will give better satisfaction to a customer than any other, and where there is much work to be done; that is, where the bells are to be often used, put in the largest size you can get. This is true economy, for a large cell will do the work better all the time, and will last much longer than the smaller sizes.

For wire to run through the house, No. 18, first-class, braided, cotton-covered office wire is excellent, although smaller and cheaper wire is often used.

The bells used will be most generally vibrating ones, and those intended merely to operate in a house need not be of a higher resistance than two or three ohms, at the highest. In some cases single stroke, or tap, bells, are wanted, and in others what is called a continuous ringer is required. The latter term means a bell which, when once started, will continue to ring until specially stopped.

The circuit-closer will generally be a simple press button, but sometimes it will require to be in the form of a spring; for instance, when used in the casing of doors or windows, to act as a burglar alarm; sometimes, also, it may be made to close the circuit when pulled instead of pressed, as in some forms of door bells.

For the present I will limit my remarks to simple bell construction, leaving burglar alarms and other similar systems out of the question.

Very little need be here said of the battery, since in other chapters it has been considerably discussed. The following additional hints may not, however, prove unacceptable.

Keep the sal ammoniac solution strong, and yet don't put so much in that it cannot dissolve. Be extremely careful to have all battery connections clean and bright, and to make them mechanically tight. Take particular care to have no leak or short circuit; nothing produces so much annoyance as this. The batteries, if properly set up, should last a year without further attention, and to prevent evaporation should be kept in a cool place; and never ought the glass jars to be filled more than three-quarters full. The amount of battery required depends entirely upon the work to be done, and practice only can enable the constructor to determine the proper amount. Two cells will generally be sufficient to ring the bells loudly all over a large house, while as much more as may be found necessary can be added for a stable line.

Although the wire for use inside a house may be cotton covered, if it has to be taken across a garden or to an out-house of any character, underground, it must be covered with gutta-percha, rubber, or kerite, preferably the latter, or, better still, use rubber-covered wire encased with lead. If the distance be considerable, it is well to run a No. 12 or 14 iron wire overhead.

The push or press buttons, which are of very simple construction, are used for closing the circuit of a battery, through the desired bell, and take the place of the lever pull of the ordinary mechanical bell. It is simply a little round box, with a button in the middle, capable of pressing together two springs with which the wires are connected. The two springs keep apart by their own resistance, but pressure on the button brings them together. They are usually fitted with platinum points, and the entire arrangement can be purchased from any dealer, and of almost any material and style.

If a pull for any special purpose, such as a door bell, be required, it can readily be made and furnished to order by any of the well known manufacturers of electrical apparatus, as also switches of any required pattern.

The bell, as already indicated, can be either a vibrator or a single stroke bell, and may or may not be fitted with an annunciator system. If a large number of bells have to ring to the same place, it is well to provide an annunciator, because then only one bell is necessary, and the information requisite in regard to the whereabouts of the ringer is furnished by the annunciator.

A single stroke bell is simply a gong fixed to a board or frame, an electro-magnet, an armature for it, and a hammer at the end of the armature, arranged to strike the gong when the armature is attracted by the magnet.

A vibrating bell has all the above parts and something more. Its armature is fixed to a spring which presses against a contact screw; the wire forming the

circuit entering at one binding screw goes to the magnet, which, in turn, is connected with the armature; thence the circuit continues through the contact screw to the other binding screw and out. When set in motion by electricity, the magnet attracts the armature and the hammer strikes the bell; but, in its forward motion, the spring leaves the contact screw, and thus the circuit is broken; the hammer then falls back, closing the circuit again, and so the action is continued *ad libitum*, and a rapid vibratory motion is produced which makes a ringing by the action of the successive blows of the hammer on the gong.

The simplest bell system that can be put up is one bell to be operated by one press button only. The arrangement of this would, of course, be the same whether the line be long or short.

Set up your bell in the required place, with the gong down or up as may be chosen; fix also your press button where it is wanted, remembering to take all the possible advantages offered by the plan of the house. For instance, a wall behind which is a closet is an excellent place to attach electrical fixtures of any character, because then it is easy to run all the wires in the closets, and completely out of sight. Next, set up your battery in a convenient place, putting it, if possible, in an air-tight box. Now, calculate how much wire will be requisite and measure it off, giving a liberal supply; for joints in inside work are very deleterious and must be left out, except where they are absolutely necessary. Cut off the insulation from the ends of the wire wherever

contact is to be made to a screw. In this simple system only three wires are necessary, *i. e.*, one from one spring of the press button to one pole of the battery, say the carbon, one from the other spring of the button to one binding screw of the bell, and one from the other pole of the battery to the other binding screw of the bell.

Let it not be thought that the caution to cut off the insulation at the ends to be connected is superfluous. On one occasion instructions were given to connect a magneto bell and a telephone, the instructor thinking that the end stripping was so obviously necessary that no instruction was needed on that; however, the apparatus would not work. It was then found that every connection was perfectly made, but that every connection was also impervious to the passage of electricity, just because the wire was not stripped. In stripping wires, don't leave any ragged threads hanging, they are apt to get caught in the binding screw, and interfere with the proper connection of the parts. After stripping the wire sufficiently, make the ends not only clean but also bright. Last, but not least, never run two wires under one staple.

It may here be said, that a button switch should be placed in the battery circuit, and closer to the battery; so that, to avoid all leakage and accidental short circuiting when the bells are not to be used for some time, it may be opened.

ELECTRIC BELL CONSTRUCTION.

PART II.

The next system is an arrangement of two press buttons in different places, each to ring the same bell.

This is very easily done. Having fixed the bell and battery as before and decided upon the respective locations of the two push buttons, run the wires as follows: One long covered wire is run from one pole of the battery to one of the springs of the most distant press button, and where this long wire approaches nearest to the other press button it should be stripped for about one inch and scraped clean; after which another wire, also stripped at its end, must be wound carefully around the bared place and the joint covered with kerite tape; the other end of the piece of wire thus branched on must be carried over and fastened to the spring of the second press-button.

It will now be seen that we have a battery wire branching to one spring of each press button. The next thing is to run a second wire from one of the bell binding screws to the other spring of the most distant press button, branching it in the same manner as the battery wire to the other spring of the second button; then connect the other pole of the battery to the second binding screw of the bell and the arrangement is complete. Now we have a continuous battery circuit through the bell when either of the buttons are pressed.

We have spoken of covering the joints with tape;

before doing so it is always a good thing to solder the joints, using rosin as a flux.

We will now assume that we are required to have two bells, in different places, but both to ring from one press button at the same time.

To do this, after erecting the two bells, the button and the battery, run a wire from the carbon pole of the battery and branch it in the manner described above to one binding screw of each bell; run a second wire from the zinc pole of the battery to one spring of the button, and a third wire from the other spring, branching it to the remaining binding screw of both bells. It must be remembered here that it will not answer to connect two or more vibrating bells in circuit one after another, as the two circuit-breakers could not be expected to work in unison; they must always be branched. That is, a portion of the main wire must be stripped and another piece spliced on to it, so as to make two ends.

There are, it is true, other methods, one of which is, if more than one bell is designed to ring steadily when the button is pressed, to let only one bell of the series be a vibrating bell and the others single stroke bells; these, then, if properly set up and adjusted, will continuously ring, because they are controlled by the rapid make and break of the one vibrator.

We will now consider a method of construction which is a little more complex, namely, to connect an indicating annunciator of any number of drops with a common bell, to be operated by press buttons in differ-

ent parts of a house. This is a most handy arrangement, and much in request, as one drop may, for example, be constructed to be operated from the front door, another from the drawing-room, a third from the dining-room, and so on. The best way to commence such a job is to sit down and think out the easy ways —where to run the wires, and all the details of the affair.

When ready to commence, the annunciator is to be fastened up with the bell near it. All the electro-magnets in the annunciator are connected by one wire with one binding-screw of the bell, and the other binding-screw of the bell is connected with the zinc of the battery. It is a good plan, then, to run a wire clear through the building from top to bottom. This wire at one end is connected with the carbon pole of the battery. It ought to be always covered with a different colored cotton from any other, so that it can readily be identified as the wire from the carbon.

Now, suppose there are six press buttons—one in each room; a wire must be run from one of the springs of each of the press buttons to the main wire from the carbon pole, and, at the point of meeting, strip the covering from both the main wire and the ends of the branch wires from the press buttons, and fasten each branch wire to the main wire; this of course virtually brings the carbon pole of the battery right into every press button.

Next lead a second wire from the other spring of each press button to the annunciator screw post be-

longing to the special drop which is desired. This will complete the circuit when any of the press buttons are pushed; for, as each annunciator magnet is connected on one side to its own press button, and on the other side to the common bell, it follows that when any button is pressed, the line of the current is from the carbon pole of the battery, through the points of the press button, back to the annunciator, thence through the bell to the zinc pole of the battery; and that, therefore, the right annunciator must drop and the bell must ring.

When bells are to be put up in handsome houses it is well to run the wires under the floor as much as possible, and to adopt such colors for wire covering as may be harmonious with the paper and paintings.

It is necessary, also, to test each wire separately, as soon as the connection is made.

It frequently happens that we are required to put up a system of bells in which the signaling is done both ways; that is, in addition to the annunciator and bell being located at one point, to be signaled by pressing the button in each room, a bell is likewise placed in each room or in a certain room whereon a return signal may be received—transmitted from a press button near the annunciator. This is a double system and involves additional wires. The easiest way to think about this is, first, to conceive of a single call bell in two rooms, each operated by a single push button in the distant room. One battery may furnish all the current required.

Run the main carbon through the house, as before, in such a manner as to admit of branch wires being

easily attached to it. Run a branch wire from it to the spring of one of the press buttons, a second wire from the other spring of the same button to the screwpost of the bell in room No. 2, and from the other screwpost of the said bell to the zinc pole of the battery. This completes one circuit. The other is then arranged as follows: The main carbon, besides being led as already described, to the spring of the press button in room No. 1, is continued to one of the binding screws of the bell in the same room; the other terminal of that bell is carried to one spring of the press button in room No. 2; the complementary spring of that press button is then connected by a special and separate wire with the zinc of the battery, and the second circuit is then also completed.

An alternative method is to run branches from the main carbon wire to all the press buttons, and from the main zinc wire to all of the bells, connecting then by separate wires the remaining bell terminals with the remaining press button springs.

In the latter plan more wires are necessary than in the former.

Although the connections of but one bell either way have been described, it is very evident that to add more is a very simple matter, as every addition must be carried out on the same principle.

When but two rooms or two points at some distance from one another, as, for example, the house and a stable a hundred yards distant, are to be connected, it is an easy plan to run but one wire, and use an earth re-

turn. If gas or water pipes are in use at both points, no difficulty will be found in accomplishing this. A strap key will in this case be found advantageous as a substitute for a press button. The connecting wire at each end is fastened to the stem of the key; the back contact or bridge of the key, against which when at rest the key presses, is connected at each end with one terminal of the bell, the other terminal of each bell being connected by wire with the ground.

A sufficient amount of battery is placed at each point and one pole of each battery is connected with the earth, the other pole being attached to the front contact of the strap key.

If it is found impossible to get a ground, the second terminal of both bell and battery at each end may and must be connected by a return wire.

In burglar alarms, the circuit is closed by contrivances similar to press buttons, but which are automatically operated by the opening of a door or window.

Automatic fire alarms can also be made by making the circuit closer consist of a thermometer, one wire entering the mercury and the other entering from above and brought into contact with the other by the mercury rising with the rise of temperature.

It is a very easy matter to add telephones to bell signaling appliances when constructed as here described. The only addition necessary is a branch or return circuit for the telephones and a switch to be operated by hand, whereby the main wire is to be switched from the bell return wire to the telephone return wire.

A very simple plan for a bell call and telephone line from one room to another, can be made as follows: Apparatus required—Two bells, two telephones, two three-point switches, two strap keys with back and front contacts, and one battery. Run one wire from the stem of the key in room No. 1 to the stem of the key in room No. 2. This is the main wire. Fix the bell and the three-point switch below it in each room. Now connect the back contact of each key, by wire, to the lever of the three-point switch, attach one of the points of the switch to one of the bell terminals, and the other bell terminal to a return wire. The return wire will now connect the second bell terminal in one room with the second bell in the other room.

The other point of the switch in each room is now connected by a wire with one binding screw of a telephone, and the other telephone screw attached by another wire to the bell return. Connecting then one pole of the battery also to the return wire, and the other pole to each of the front contacts of the keys, the system is complete. When at rest each switch is turned on to the bell. To ring the bell in the other room the key is pressed. The battery circuit is then from battery, front contact of the pressed key, stem of key, main wire, stem of distant key, switch, bell and, through return wire, to the other pole of the battery. After bell signals are interchanged the three point switches are transferred to the telephone point and conversation can be maintained.

By following the foregoing instructions many simple

devices of bell ringing can be constructed, and good practice acquired for more complicated work, which will soon come, and which, besides the cash recompense, carries with it a rich reward in the shape of increased knowledge.

HOUSETOP LINES, POLE LINES AND AERIAL CABLES.

Which? This is the question that to-day is before the telephone men of America. The subject is a prolific and important one, and deserves careful consideration.

At the advent of the speaking telephone, or even at the outset of the telephone exchange system, none were so daring as to prophesy or venture to forecast its future. Yet, at the present writing—April, 1882—and it is well to put it on record for future information and comparison—there are at least 175,000 telephones in operation—counting each transmitter and receiver—with a monthly increase of over 4,000.

In some of the larger cities the managers of the telephone companies have begun to realize that there is practically no limit to the telephone exchange business when it is actively pushed.

When we started out, in the winter of 1877 and spring of 1878, although no one was able to guess what the outcome would be, it was early seen that rapid construction was a desideratum. In the spring of 1878 the first glimmer of opposition and rivalry commenced, and by the autumn of that year it was as hot as ever any war of trunk railroads could possibly be.

In Indianapolis, Chicago, Fort Wayne, Toledo and many other places the competition was so violent that frequently the telephone was given to the subscriber for nothing. Often the subscriber was indifferent as to whose telephone he should have, and the result was that

the first man getting a telephone fixed on the premises was, by a kind of preëmption, the one to secure the victim.

It can easily be imagined that under these circumstances, in many cases, good line construction was regarded as quite a secondary matter. The main idea was, get your lines up, do it well if you can, but get them up. Carrying this out a little further, we can see that as it would take time to cut and plant poles, and also to get the right to plant poles, it was an easy way out of the woods to erect rickety structures of spruce and pine on other people's housetops.

It was soon found, however, that the visits of the spurred and tomahawked lineman to a roof were made to shoulder and pay for such a multitude of leaky roofs that, in many places, the pecuniary advantage of using another man's property as your line supports ceased to be discernible.

Then came the era of poles. Pole lines of unusual size were constructed, in many cases on both sides of the principal streets of the cities, 30, 40, 60 and even 70-foot poles became rapidly the rule, and as rapidly became filled with telephone wires, and for a very short time it looked as if everything was lovely and no more trouble would be experienced. It was found that line troubles were greatly diminished by the use of pole-lines, and that when they did occur they were much more easily handled than before.

It was found that the wires were no longer subject to interruptions from the linemen of foreign companies,

and if crosses occasionally appeared, there was no one to object to the climber at once clearing it. But even this happy state of affairs is no longer equal to the situation. Every man who uses the telephone in his business wants a special line. When he wants to use the telephone he wants to use it, and don't you forget it. He does n't want to be told, or to find out without telling, that Snickelfritz, down the street, who is running a heavy opposition to him in business, has the line ahead of him.

Now, several of our large cities have upward of 2,000 subscribers, and at their present rate of increase are good for five thousand inside of four years. Two thousand subscribers mean 2,000 lines, and 2,000 lines fill up an office fixture and cupola pretty well, and we have got to contemplate an almost indefinite increase. Obviously some expedient is necessary. What shall we do?

Only one remedy seems to offer itself with any prospect of filling the bill, *i. e.*, aerial cables. By entering your central office with these, and running them out, say two thousand feet for a start, on each side from the office, an incredible amount of space is gained; and as a matter of hypothesis, it is the belief of the writer that fifty wire cables are perfectly practicable for a much greater distance.

The kerite cable of A. G. Day, with the anti-induction appliances, is a very good one, and is used to a certain extent in Cincinnati, where Mr. Eckert has fitted it with an ingenious hanger of copper or galvan-

ized iron, by which it is appended to a stout wire or strand.

E. F. Phillips also makes a good cable, rubber covered, with a casing of material resembling bagging.

The Bishop Gutta Percha Works manufacture a lead-covered anti-induction telephone cable that is largely used by the Metropolitan and other telephone companies.

In addition to these, the Western Electric Manufacturing Company has recently made important improvements in telephone cables, and claims to be able to supply a very excellent cable at a much lower price than has heretofore been charged.

Thus we see that our cable and insulated wire manufacturers are keeping as well abreast of the demands of the business as have the makers of switch boards and magneto bells in their department.

My own opinion is that the electrical disturbances expected from induction and leakage in these cables have been much overrated, and that the very multiplicity of wires is a practicable eliminator of troubles accruing from these causes.

A very good plan is to purchase the first cable fitted with the anti-induction remedies, and try it with the outside metallic covering both grounded and ungrounded. If it works well the latter way, it may be concluded that such appliances can be dispensed with.

ANTICIPATIONS OF GREAT DISCOVERIES AND INVENTIONS.

One of the most singular features in the history of electrical and telegraphic science is that of periodic anticipation.

There would seem to be, at least for the last century and a half, a select class, partly composed of idealists, partly of discoverers and partly of inventors, who are invariably about twenty years in advance of the times in which they live, and who imagine, discover or devise some great and hitherto unheard of thing, give it just enough publicity to enable it to be fished up out of its obscure retreat in the course of time, and then suffer it to die away and, on account of the unprepared state of the scientific world, to be totally forgotten until some smart individual, who frequently is also a celebrated scientist, rediscovers, in perfect good faith, the same thing and keeps it well before the world till its advantages are fully perceived. His name then goes down to posterity associated with the discovery, the second inventor being covered with glory and the first being totally unknown to fame. Yet, in the course of still another twenty years, the name of the obscure originator of the brilliant idea is revived by some telegraphist or engineer who, like Latimer Clark, has a taste for archæology, and a certain portion of the credit due to the originator is tardily awarded him. Many such cases have been made public in various ways, within the last few years and, although it can be but poor satisfaction to

an inventor to have his talents and originality recognized only after he is dead, still tardy recognition is better than none ; and, at all events, the knowledge of the earlier invention is beneficial to those who read thereof.

It is not thought that a complete list of these anticipations has ever been published in any text book; and it is, therefore, hoped that the following account which is as copious as the material at the command of the author can furnish, will be interesting and novel :

It is generally thought that Galvani was the first to notice the convulsive movement of the limbs of a frog when acted upon by electricity. It is true that he did, as stated by himself in a work published at Bologna, in 1791, for the Institute of Sciences, notice this phenomenon, and many accounts of the matter make his wife even more conspicuous in the affair than himself. It is also true that the phenomenon was new to him and that he, entertaining the opinion that muscular action is caused by electricity, regarded the phenomenon as corroborative of that view and pursued the inquiry with zeal; and, as is well known, the science of current electricity has, on this account, often been called "galvanism." Yet, referring to certain records, notably the History of the Royal Academy of Sciences, published in Paris, in the year 1700, we find that a person named Duverney did, as early as that year, ascertain that a defunct frog made an excellent electroscope. Let us here be thankful that the frog department lay dormant so long. We tremble at the bare idea of a science called "Duverneyism."

In the year 1800, the Italian philosopher Volta wrote to Sir Joseph Banks, then president of the Royal Society, announcing his arrangement of moistened discs of silver and zinc which has ever since been known as the "voltaic pile." This might be said to have been partially anticipated by Mr. Sulzer, of Berlin, in 1762, who noticed the peculiar taste occasioned by a piece of silver and a piece of lead when placed in contact with each other and with the tongue; but it is fully and broadly met and circumstantially and completely antedated by a publication of a Dr. Fowler, of Edinburgh. It is believed that the account has never hitherto been published in the United States, but may be found in Vol. I of the 1852 edition of the *Encyclopedia Britannica.*

The article in question reads as follows:

"ROBISON'S ANTICIPATION OF VOLTA'S PILE."

"John Robison first thought of increasing the heterogeneous contact by using a number of pieces of zinc made of the size of a shilling, and making them up into a rouleau with as many shillings.

"We have here unquestionably the first idea of the pile, which moreover was actually constructed. This was in May, 1793.

"It was only applied however to excite the nerves of the senses."

Much as we dislike the duty of interfering with the origin of magneto-electricity, to make our record complete we must acknowledge that its production was at

least hinted at and perhaps experimentally discovered just after Volta's announcement of the battery. For, in the *Monthly Magazine*, an English periodical, we find as early as April, 1802, the following singular statement, which is said to have been contributed:

"Galvanism is at present a subject of occupation of all the German philosophers and chemists. At Vienna an important discovery has been announced—an artificial magnet, employed instead of Volta's pile, decomposes water equally as well as that pile or the electrical machine; whence it has been concluded that the electric, galvanic and magnetic fluids are the same."

Taking a derived circuit now into the mathematical region of electricity, we find that even the much quoted Ohm's law is not free from the same fatality, but that a very similar law was laid down in January, 1781, by the Hon. Henry Cavendish. This is rather surprising, seeing that Prof. Ohm did not independently discover or formulate this law until 1827, and that it was not even till long after the latter date that its importance was fully appreciated, and that the measurements of electric resistance became a fully recognized branch of research.

Diverging back to electricity, physically considered, we find that one of the most important and frequently used instruments employed in electrical measurements is the Wheatstone's Bridge. Some persons who habitually use this instrument may be surprised to hear that Wheatstone's Bridge is not Wheatstone's Bridge at all, but Christie's. It was invented and brought before the Royal Society in 1833, by Mr. S. Hunter Christie,

of the Woolwich Military Academy, and its description is given in the *Philosophical Transactions*, dated February 28, 1833. He used it to measure the relative conductivity of different metals at different temperatures. He made strenuous attempts to give popularity to his invention, but in vain, and not until revived, in 1843, by Sir Charles Wheatstone, who, in a vigorous paper on electrical measurement, again described the bridge, giving due and full credit to Mr. Christie, was the apparatus brought into use.

Another prominent case is that of the dynamo-electric machine. October 14, 1854, a Danish or Swedish electrician, named Soren Hjorth, patented what he called "an improved magneto-electric battery," which was actually a machine constructed on the now well known principle of mutual acceleration and accumulation. He describes it in his patent as follows: "The coiled armatures revolve between the poles of fixed cast-iron permanent magnets, and of fixed electro-magnets; and thus generate electric currents in the armature coils, which are allowed to pass round the electro-magnets, and a mutual and accelerating force is produced by this means between the electro-magnets and the armatures."

In spite, however, of this patent and its publication, this same idea was quiescent from the date of patenting until 1866, when another patent for substantially the same invention was taken out by Alfred Varley, while two other eminent scientists, in February, 1867, exhibited machines embodying the principle, and de-

livered papers fully describing the invention and its application. These were Wheatstone and Werner Siemens. The discovery was regarded at that late day as one of the most wonderful of the century. Hjorth was, however, the original inventor, and Wheatstone was one of the first to acknowledge this when the patent of Hjorth was brought to his notice.

The wonderful ring armature magneto, or dynamo, electric machine of Gramme is clearly anticipated by the ring machine of Dr. Antonio Pacinotti. This machine was devised in 1860 and produced a continuous current of given direction. The Gramme machine was produced in 1871, and the difference between the two is entirely one of detail of construction.

In 1854 Cromwell F. Varley took out a patent for a gravity battery which, besides covering the ordinary form, also described several other varieties, one of which has been since patented by Sir William Thomson—once as the Menotti battery, and once as the Marie-Davy.

It is rarely that Mr. Varley gets any credit for his own battery. Mr. John Fuller was, however, in 1853, the first to introduce the gravity battery.

On the principle that people who live in glass houses do sometimes throw stones, we find Mr. Varley, in 1868, patenting in the United States, No. 75,492, the very same method used long before in England for carrying away currents which leak from any wire on a series of poles to the earth, instead of permitting them to find their way to other wires on the same poles. The first inventor of this improvement was Edward Highton,

and it may be found in his patent of January 29th, 1852.

I have cited the foregoing cases under the impression that the facts contained therein are of general interest. It is, we thus preceive, just as bad to be too early as too late.

It is a very curious study to observe how discoveries and inventions that have passed away and been neglected, because circumstances were not favorable to their development, are revived as soon as a suitable time arrives, either by accident or by original research and ingenuity, and become important elements in the advance of science and the progress of civilization.